INSTITUTION NUMBER.

[Registered as a Newspaper.

CHEMICAL LIBRARY GENERAL LIBRARY JUN 15 UNIV. OF MICH.

GAS JOURNAL

LIGHT • HEAT • POWER • BYE-PRODUCTS

[Founded in 1849 as the "Journal of Gas Lighting."]

VOL. CXLVI. No. 2925.] LONDON, JUNE 3, 1919. [71ST YEAR. PRICE 1s.

OXIDE OF IRON
SPENT OXIDE

GAS PURIFICATION AND CHEMICAL CO., Ltd.
PALMERSTON HOUSE, LONDON, E.C. 2.
Telegrams: "PURIFICATION, LONDON."
Telephone: 9144 LONDON WALL.

PUMPING ENGINES
All Types for ACID, &c.
CAST-IRON OR STEEL TANKS
Any Capacity.
CHEMICAL PLANT.
Roofs and Girders. Structural Work.
Air and Gas Compressors.
MIXERS.
TAR STILLS AND CONDENSERS.
SULPHATE OF AMMONIA PLANT
W. NEILL & SON, LD.
Engineers, Iron & Brass Founders,
ST. HELENS JUNCTION.
Telegrams: 'NEILL, ST. HELENS.' Telephone No. 20.

PURIFYING MATERIAL
"Brownox-de-Luxe."
Unqualified Satisfaction given where used.
SPENT OXIDE PURCHASED
J. BROWN & CO., Ltd.
Savile Town, DEWSBURY.

TORBAY
JOINT STOPPING
FREE FROM LEAD.
The TORBAY PAINT CO.,
26/28, Billiter St., LONDON, E.C. 3.
39/41, Old Hall St., LIVERPOOL.

"BLUEBELL"
SILICA RETORTS
(95% SILICA)
John G. Stein & Co., Ltd.,
Castlecary, SCOTLAND.

Makers of
GASHOLDERS,
TANKS (C.I. or Steel),
PURIFIERS,
WASHERS,
ROOFS,
&c.
ASHMORE, BENSON, PEASE & CO., LTD.,
STOCKTON-ON-TEES.
Complete GAS WORKS
London Office:
28, Victoria Street, Westminster, S.W.
Telegrams: "GASHOLDER."

W. & B. COWAN
(Incorporated in Parkinson and W. & B. Cowan, Ltd.),
LONDON. MANCHESTER. EDINBURGH. GLASGOW.
SYDNEY. MELBOURNE. BRISBANE. WELLINGTON, N.Z.
(See Advertisement on page III. of Wrapper.)

JAMES McKELVIE & CO.
Coal Owners,
Gas and Steam Coal Contractors,
17, RUTLAND SQUARE, EDINBURGH.
59, MARK LANE, LONDON, E.C.
GUILDHALL CHAMBERS, SANDHILL, NEWCASTLE-ON-TYNE.
24, CHAPEL STREET, LIVERPOOL.
ESTABLISHED 1840.

STEWARTS AND LLOYDS, LIMITED, 41, OSWALD STREET, GLASGOW. BROAD STREET CHAMBERS, BIRMINGHAM.
TUBES & FITTINGS for Gas, Steam, Water, &c.

GEORGE GLOVER & CO., LTD.,
DRY GAS METER MANUFACTURERS.
Agents for the Patent "M & M" SELF-LOCKING SLOT-METER PADLOCK.

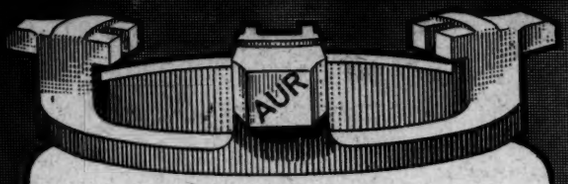
The STRENGTH and SECURITY of the **"M & M"** Lock depend not upon its EXTERNAL SHAPE, which has been imitated in various quarters, but upon the SPECIAL CONSTRUCTION of its INTERNAL MECHANISM.
The special mechanism, consisting of a sliding bolt fitted with TWO STUMPS and DOUBLE-ACTION LEVERS, is FULLY PATENTED.

See that each lock is stamped **M & M,** *and beware of inferior imitations.*

LONDON:
ROYAL AVENUE, CHELSEA, S.W. 3
TELEPHONE: 1140 Kensington.
WIRE: "Dry Meters, London."

LEEDS:
9, DEWSBURY ROAD.
TELEPHONE: No. 2934.
WIRE: "Meters, Leeds."

MANCHESTER:
GAYTHORN METER WORKS, EASTON STREET.
TELEPHONE: No. 6898 City.
WIRE: "Slot, Manchester."



The Welsbach Light Co., Ltd.

THE
WELSBACH
LIGHT CO., LTD.
Welsbach House,
KING'S CROSS,
London, W.C.1
There Are No Better Mantles Made

is an ALL British Company

The Welsbach Factory produces the largest number of Mantles of all Factories in the United Kingdom.

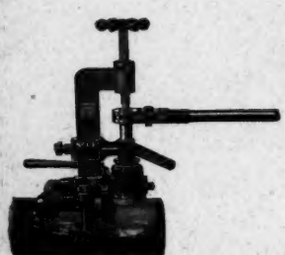
SERVICE CLAMPS, TAPPING & DRILLING MACHINES,

For Steel or Cast Iron Mains.

Century Pattern.

Every Drilling Machine unconditionally guaranteed.

High Pressure Gas Service Set.

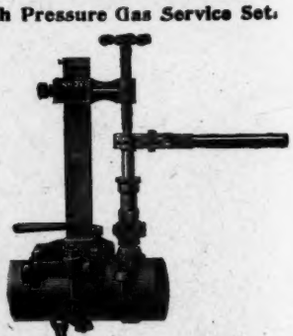


No. 14. For Tapping Dead or Live Low-Pressure Mains.

MUELLER HIGH-PRESSURE GAS COCKS, Extra heavy Type.

No. 19. For Drilling High-Pressure Gas Mains or Water Mains.

DISTRICT AND SERVICE REGULATORS.



No. 21. For Drilling High-Pressure Gas Mains or Water Mains.

Sole European and Colonial Licensees—

THE BRYAN DONKIN CO., LTD., Engineers, CHESTERFIELD.

London Office: 3, VICTORIA STREET, WESTMINSTER, S.W. 1.

Chesterfield Telephone No. 84.
London Telephone No. 5358 Victoria.

Chesterfield Telegrams, "Donkin Chesterfield."
London Telegrams, "Donkin Vic. London."

CONTENTS.

EDITORIAL NOTES.

The Institution Meeting 559
The President on the Position of the Gas Industry 559
Gas Investigation Committee's Report . . 560
Coal Situation and Gas Standards Question . 561
Increased Depreciation Allowance for Income-Tax—Oil in England—Benzol Power Tests 562

INSTITUTION OF GAS ENGINEERS.

ANNUAL MEETING IN LONDON—

Review of the Proceedings 563
Reception, Dance, and Music—New Members and Associates 572

General Report—

The President's Welcome—Confirmation of the Minutes—Appointment of Scrutineers—Visitors from Overseas—The Presidential Address—Coal Stocks. . 573
Annual Report and Accounts—A Separate Meeting 574
The Case of the Ex-Service Man—Report of the Gas Investigation Committee 575
The Question of Inerts 576
One B.Th.U. not as Good as Another . 577
Good Results with 38 p.ct. of Inerts—American Experiments 578
The Reports Criticized—Prof. Smithells Replies 579
The New President—Other Officers—The Benevolent Fund Meeting . . . 580

A Message from France 588
Report of the Refractory Materials Committee 588
Report of the Life of Gas-Meters Joint Committee. 592
Further Development of Spraying . . . 592
A Message from the Italian Association . 601
New Honorary Members—Place of Next Meeting 605

INSTITUTION OF GAS ENGINEERS (*continued*)—

Papers and Discussions—

The Education of a Gas Engineer. By Prof. Smithells. 582
The Inter-Relation of the Gas and Dye Industries. By W. B. Davidson, D.Sc. 596
The Application of Reinforced Concrete to Purifier Construction. By A. E. Broadberry, M.Inst.C.E.. 601
Some War Experiences of British Gas Undertakings. By H. Townsend, M.Inst.C.E.. 624

Special Committees' Reports—

Report of the Gas Investigation Committee 607
Report of the Refractory Materials Committee on the Crushing Strength of Firebricks 619
Life of Gas-Meters Joint Committee: Interim Report on the Internal Corrosion of Mains and Services 622

National Gas Council of Great Britain and Ireland—Central Executive Board Meeting 633
Société Technique du Gaz en France—Programme of the Victory Congress. . . . 633
National Illumination Committee 633
Electricity Supply Memoranda 634
Personal 635
Masonic—The Evening Star Lodge and the Institution of Gas Engineers 635
Coal Substitutes for Gas-Making 635
Continuous Vertical Retorting on the "Dempster-Toogood" System. 636
London and Southern Junior Association. . 636
A New Prime Mover—The Still Internal Combustion Engine 636
Improvement in Gas Incandescent Lighting. 637
Preparing Lubricating Oil for Re-Use. . . 637

CORRESPONDENCE.

Prof. Smithells and Last Week's Discussion on "The Education of the Gas Engineer" 638
Mr. Samuel Glover's Remarks on Steel Tubes, &c. 638

PARLIAMENTARY INTELLIGENCE.

House of Lords—
Progress of Bills. 638
House of Commons—
Progress of Bills. 638
Miners' Hours and Coal Output 638
Mantle Import Prohibition 638
Proposed Change in the Method of Charging for Gas. 638
Private Wagons and the Transport Bill . . 638

REGISTER OF PATENTS.

Applications for Patents 638

MISCELLANEOUS NEWS.

Monte Video Gas Company—An Increased Dividend 639
Cape Town and District Gas Light and Coke Company—A Record Make of Gas . . . 639
Nottingham Gas Undertaking—A Profit of £95,029 641
Improved Results at Blackburn—One of the Best Years on Record 642
New Verticals for Leicester 643
Rotherham Gas-Works Accounts 643
Road Tarring and Fisheries. 644
Dublin's High Electricity Charges. . . . 644
Current Sales of Gas Products 644
Stock Market Report 646

PARAGRAPHS.

Eliminating Radiation Losses in Water Boiling—Standard of Calorific Power Act—Municipal Ownership in Missouri—Statutory Undertakings (Temporary Increase of Charges) Act 562
Fertilizer Orders Suspended. 635
Wages at Halifax—Gas and Electricity Extensions at Manchester 645
Maximum Bye-Products, Ltd.—British Dye-Stuffs Corporation, Ltd.—Salford Gas and the Rates—Dublin Public Lighting Estimates 646
Drogheda Gas-Workers' Strike—Debenham Gas Company, Ltd.—Gas-Meter Testing at Birmingham—Dearer Gas at Evesham—New Gasholder for St. Ives—Opposition to Coal Nationalization—Nottingham Public Lighting—Presentation to Dundee Corporation Official—Teignmouth Gas Supply . . 647

HUMPHREYS & GLASGOW, LTD.,

AND

THE UNITED GAS IMPROVEMENT CO., U.S.A.

WATER GAS

BLUE *AND* CARBURETTED.

Humphreys & Glasgow, Ltd. 368,400,000 Cubic Feet Daily.

The U.G.I.Co., U.S.A. - - 777,900,000 Cubic Feet Daily.

OVER ONE THOUSAND MILLIONS CUBIC FEET DAILY.

38, VICTORIA STREET, LONDON, S.W.

Bureau de Bruxelles: 82, Rue du Trone, Ixelles.

THE VALUE OF EXPERIENCE.

THIS 200-LIGHT METER, SUPPLIED IN 1868, IS STILL REGISTERING CORRECTLY.

WE HAD 24 YEARS' EXPERIENCE in making Dry Meters when we supplied this meter.

We have had 51 years' experience since then.

THOMAS GLOVER & CO., LTD.

(Original Makers—Established Three-Quarters of a Century),

GOTHIC WORKS, ANGEL ROAD, EDMONTON, LONDON, N. 18.

Telephone: 41 Tottenham (3 lines). Telegrams: "Gothic 'Phone, London."

London Show-Rooms: 25, PRINCES STREET, OXFORD CIRCUS, W.1.

Gothic Works, King Edward Road, BIRMINGHAM; 18, Severn Street, Deansgate, MANCHESTER; Gothic Ironworks, FALKIRK; 82, Gordon Street, GLASGOW; 97, Millfield, BELFAST; and 333, Queen Street, MELBOURNE.

PARKINSON'S

Ordinary & Prepayment Meters.

Accurate in Registration.

Reliable in Working.

High-Class Workmanship.

W. PARKINSON & CO.,

(INCORPORATED IN PARKINSON AND W. & B. COWAN, LTD.)

COTTAGE LANE, CITY ROAD, LONDON.	BELL BARN ROAD, BIRMINGHAM.	HILL STREET, BELFAST.
Telegrams: "INDEX, LONDON." *Telephone Nos.:* 7570 City.	"GASMETERS, B'HAM." 2345 Midland, B'ham.	"PREPAYMENT, BELFAST." 3374 Belfast.

GAS JOURNAL

LIGHT ✂ HEAT ✂ POWER ✂ BYE-PRODUCTS

[Founded in 1849 as the "Journal of Gas Lighting."]

EDITOR & PUBLISHER: WALTER KING. OFFICE: 11, BOLT COURT, FLEET ST., LONDON, E.C. 4.

VOL. CXLVI., No. 2925.] TUESDAY, JUNE 3, 1919. [71ST YEAR.

EDITORIAL NOTES.

The Institution Meeting.

THE first annual meeting of the Institution after the war has come and gone; and it was in every respect highly successful. The whole combination of circumstances fitted in to make it so. Glorious weather, a large attendance of members, a not over-loaded programme, subjects apposite in respect of time and conditions for consideration, and a President (Mr. Samuel Glover, M.Inst.C.E.) who was keen for the maximum result from the fare provided and the time at disposal, and who did much himself to keep the sittings well up to the mark. The meeting was notable. It was regularized to the old pattern; but the whole atmosphere was new, and fresh ideals and considerations bulked largely in the proceedings. There is, on the one hand, the damage occasioned by the war to be repaired; on the other, there are the changes in work and method that have to be dealt with, despite the obscurants in the path, whose peculiar mentality harbours the belief that it is not wise to allow the industry to progress by the aid of new knowledge, and that it is better to stabilize its old conditions, though this undermines its strength for good service. The industry has no intention to allow itself to be stopped from traversing the path of progress; but it will have to put up a resolute fight for its rights, though instead of having to fight for them, the Government and every local authority ought to be urging the industry to bestir itself in reshaping its course and extending its service.

We heard of these things in the President's Address; they had their representation in reports, papers, and discussions. The Gas Investigation Committee's report, describing the work carried out by Mr. J. W. Wood, under the direction of Prof. Cobb, deals with matters bearing on a fundamental change in the industry's methods and policy, which change is strongly invited by national interests and economic circumstances. One change may bring some others which are not contributory of good but rather of harm; and in the report of the Gas-Meter Research Committee—prepared by Mr. J. G. Taplay and Mr. B. R. Parkinson, and dealing with the internal corrosion of mains and services—we see (as we saw last year in their contributions to the proceedings) how new methods of manufacture subscribe to destruction in the distribution system, but how readily, and by what simple means, they can be avoided. The great developments in the industry and the heavier responsibilities call for men of strength of character and intellectual capacity. Prof. Arthur Smithells opened a discussion upon the training of the gas engineer properly fitted, according to current estimates, for the future; and, if we read carefully the paper or lecture of Dr. W. B. Davidson on the "Interrelation "of the Gas and Dye Industries," we see striking illustrations of the profitable investment that men are whose training has systematically combined science and practice. Economy is likewise a matter for the future—economy in capital expenditure, economy that can be derived from ensuring the fitness of things to work, and economy in any and every process. The work of the Refractory Materials Committee is a means to an end. Increase of fitness and durability of fireclay materials and goods produces economy; and so does the utilization of reinforced concrete in the manner described by Mr. A. E. Broadberry for purifier construction. There was only one item which did not deal in some way with the future, but which has value as an historical record, and will often be referred to in the future. This was Mr. H. Townsend's narrative of the damage done to British gas-works during the war by bombardment from sea or air, or by explosion at works engaged on munitions production.

But no matter the direction in which we survey the past week's work [which is fully dealt with in our "Review of the Proceedings" commencing on p. 563], we see the steadily flowing currents which are carrying the industry, it is hoped, to still greater service and permanent prosperity. We share fully the feeling of satisfaction of the members generally over the success of the meeting, which success will have a manifold increase if it is the means of stimulating the interest of more of the members in the great problems that must be dealt with if the industry is to occupy its rightful sphere, and that to the maximum extent of its power.

The President on the Position of the Gas Industry.

ENTHUSIASM and confidence are to-day wanted of every man in responsible position in the gas industry; for such qualities are more than ever helpful at this time. They are the qualities which directed his pen as the President indited the address to which the members listened last Tuesday morning. No one within the industry needs telling how it has been battered about by the war and its issues—in those conditions that are fundamental to prosperity, finance and costs of materials; and no one within the industry requires to be told what it has accomplished (though the public and the makers of legislation should have it impressed upon them on every possible occasion) to help in the days of peril in a way that no other industry could have done. That is now of the past; but it should nevertheless have due recognition, with material reciprocity. Mr. Glover in his address tells us that now we have to set to work to find our true position; that we must see "how quickly we can arrive at the place "whither we are bound, deliver the goods, and obtain re-"turns." We like the figurative language that covers the advice, and that urges action. There is, however, in mind, a disturbing question. It is this: Is the industry setting to work in the right course to find out its true position, and to get to work quickly to attain its place in the reconstruction and development of the country's affairs? What the onlooker sees is that the industry is now actively setting forth its good qualities as coal conservators, as producers of necessaries for the community and for important industries external to itself. It has proved indispensable in times of war for national defence and victory over enemies; and it has proved itself indispensable in the national system which (so the war has taught us) should be developed on the principle that the correct thing for any country is to realize the maximum independence possible in ministering to its own requirements in peace or war. In short, the gas industry has proved itself to be a "key" industry.

To show all this is very right and proper. There must be no neglect in this respect. But are we at the same time doing all that could and should be done in constructing the case which would prove how the industry is handicapped by difficulties which have broken down all that goes to make industry and commercial work at all possible in the highest degree? The potentiality of the industry is enormous; but the potentiality cannot be fully materialized under the weight of ill-conditioned finance and of encumbering regulation. What clearly our legislators have yet to learn is that regulation should be so fashioned that it will not resist progress or prevent or delay the attainment of maximum advantage. Are we now at work finding the true position in these matters, so that we can quickly "arrive at the place whither "we are bound, deliver the goods, and obtain returns?"

We see no definite evidence that we are, though this work is as exigent and necessary to the industry as are the certificates of good character and of genuine merit. The President is optimistic regarding the National Gas Council. So are we; and we, most of all people, do not want to harass the Council. But as the President indicates, there is no time to lose; and the very existence of the reorganized National Gas Council should, in our opinion, make for alacrity in realizing, through the co-operation of the best brains of the industry—men specialized in law and finance—the supplement that is essential to the case already formulated, which only discloses part of the position of the industry, and that the part which is the least troublesome to handle, though even that has never been properly done before. The industry wants nothing but fair play, which means larger freedom and revised financial conditions. Then the Government may at its own sweet will go on with its electrical schemes, which are founded on preferential consideration for electricity supply. Against that, with freedom and with proper financial terms, the gas industry will be quite prepared to prosecute its fortunes on merit alone.

Not only optimistic, but broad-minded, the President has no sympathy with those people who grieve to think that the Institution is no longer the supreme representative of the industry's affairs. Those people who think this a pity have little sense of proportion or of fitness—not in respect of personal capacity, but in constitution and power. They divulge the fact that they have no proper conception of what the industry as a whole means, nor of what is constitutionally necessary to represent it as a whole, nor of the authority requisite to do so. In its Institution the gas profession possesses the only fully representative technical organization of the industry; and the extensions day by day show the illimitable scope of the technical work that there is. On the other hand, each meeting of the Institution declares how little advance has been made, through systematic and co-operative endeavour, in research into fresh practices, in the sifting of the useless from the valuable, and in presenting the best practices for the common benefit of the industry. The work of the technical men of the industry must be predominant in subscribing to its best interests; but, though predominant, there is much else that is accessory and essential, and without which there would be no technical gas work. The very existence of the National Gas Council will bring home to gas administrators the importance of the technical work more directly than anything else could possibly do; and the National Council can, and will no doubt, be made the channel through and by which the Institution will be enabled to do greater work for the industry, and so multiply the peaks, and narrow the distances between future ones, on the industry's chart of technical progress.

And the technical progress has already been great, and diverse. One salient effect has been that it has, while enlarging service, been the means of conserving coal. The demand for light, heat, and power extends year by year; our coal resources are a diminishing quantity. National interests ask that coal shall be used in the most economical manner, which means conservation relative to needs. The President shows that, with an expansion of business, the industry has substantially reduced its coal consumption per unit of gas output. If gas make had continued at the old standard of 10,000 c.ft. per ton of coal, instead of 12,500, another 7 million tons of coal would have been required annually to meet war-time demands. The Coal Controller has something for which to bless the gas industry. But the work of these latter years avows the possibility of the industry running up to 18,000 or 20,000 c.ft., and some people are making a bolder bid, which means supplying the community with 8 to 10 million B.Th.U., and more, compared with (say) 6 million B.Th.U., in gaseous form per ton of coal carbonized. But these things cannot be generally done, all the service indicated by the President cannot be rendered, without the industry is allowed to give satisfaction on just lines to its invested capital. The President made this point; but outside we hear that belief. amounting to pure assumption, is entertained that any appeal to Parliament would be met with the reply that the industry has already been granted relief. Relief from what? Nothing but absolute wrecking. There has been no relief based on justice to the capital invested in the industry. Since the inquiry that gave birth to the monstrous injustice, things have changed considerably, and for the worse; and it is for Parliament to be made to understand now that there is no chance of the industry, under conditions that are being promoted into an unpleasant durability, being able to sustain its position as an indispensable part of the national system unless there is positive relief from the absurd position in which the capital has been placed by the act of Parliament itself. Let Parliament look on the electrical picture as painted and framed by itself, and then upon the gas picture as it has made it. Having done this, let it ask itself whether the latter becomes the British Legislature. We see only one answer. There is hesitation to approach Parliament. The position which the President asserts that we must find has been thought about, but has not yet been seriously sought. If we are wrong, then activity in the seeking is at any rate somewhere beyond our vision.

There is much else in the address; but this is the topic for the hour. In what are we lacking that there is not a pressing forward to the attack of the problem that is impeding the movements of the industry? Was the President right in his final words: "There is great need for men of "courage and right vision to guide the industry to its right-"ful position in the service and confidence of the nation?" If this be true, then most heartily we join in his prayer, "God give us men."

Gas Investigation Committee's Report.

Technically speaking, the second report of the Gas Investigation Committee was the most important part of the proceedings at the meeting. Our only hope is that this and the former report will not be wrongly interpreted by laymen who do not possess the necessary qualification for reading them properly, and placing upon them their true value. Broadly speaking, the lessons of the present report for our legislators and for gas consumers are that, notwithstanding perfect gas-consuming appliances have not been employed for the lower grades of gas, the tests do show that, as the calorific power descends to the point at which tests have been made (with gas of 388 B.Th.U. gross), the efficiency obtained is proportional to the potential heat units carried by the gas; and that for domestic purposes a very high percentage of inerts makes no appreciable difference to the results, excepting that, if the CO_2 is unreasonably high, it would affect flame temperature for mantle incandescing, as it does in industry in certain metallurgical work. But, on the other hand, the report shows that a low calorific power gas can be made, where manufacturing conditions are of modern character (which they are not, and cannot be for some time, in all cases), with considerable coal economy, and therefore at a cheaper rate, without an unduly high percentage of inerts. The two facts are highly important as bearing upon the report of the Fuel Research Board. In the first place, they show that consumers would be well protected by purchasing gas on the potential heat unit basis, and also that there is no necessity so far as consumers are concerned for any such low restriction of inerts as is proposed by Sir George Beilby and his colleagues. The consumer, in short, is amply protected by the sale and purchase of gas on the heat unit basis.

However, as Mr. Jacques Abady points out, there is the danger of non-technical men looking at the report cursorily, or not appreciating the conditions under which the testing has been made; and Mr. W. W. Townsend calls attention to the point that certain rather definite statements in the first report are apparently negatived by the present one. As to the former point, the Committee have been working on a very definite line—taking first consumers' appliances as they exist, now making modifications to the orifices of burners to suit the lower grade of calorific gas (so as to obtain a sufficient supply of B.Th.U., and proper aeration, to prevent lighting-back); and then, in the next stage, they are proposing to pursue the tests with gas-consuming appliances specially designed for the lower-grade gas. In the first tests, there was no modification of the orifices of the burner nipples for the lower grades of gas, and in the upright incandescent burner tests, chimneys were not used, both of which conditions badly affected the results. So we are told in this report that corrections must be made in the figures in the first report if comparison with them is to be made. In our opinion, quite the proper thing to be done would be to abandon entirely the data in the first report, and not attempt to apply any arbitrary correction to them, for the tests were not carried out in a manner—for instance, in the case of the upright burners—which justifies the low thermal efficiency figures per candle-hour for the lower calorific power grades of gas. Then we have it stated that, with

the incandescent lighting burner, taken as representing the most stringent requirements of high temperature domestic use, the maximum efficiency under test conditions (with the Uddingston steamed vertical retort gas of 347 B.Th.U. net) is a little lower than the best obtainable with gas of a higher calorific value. The difference is indeed so small that it was unnecessary to call attention to it; for Table XL. shows that, supplying per hour 2200 B.Th.U., with 556 B.Th.U. net coal gas, 38·2 candles were obtained per 1000 B.Th.U.; whereas in the case of the Uddingston 347 B.Th.U. net gas, supplying 1800 B.Th.U. per hour, 34 candles per 1000 B.Th.U. were obtained. The difference, therefore, is immaterial, though there is so great a difference (209 B.Th.U.) in the net calorific power.

From the table we get further remarkable testimony. The 516 B.Th.U. net gas, containing 13 p.ct. of blue water gas, gives 41·5 candles per 1000 B.Th.U., or 3·3 candles more than the 556 B.Th.U. net coal gas; and the 486 B.Th.U. net gas, containing 23·8 p.ct. of blue water gas, is equal in candle power per 1000 B.Th.U. supplied to the 556 B.Th.U. net coal gas, while the 455 B.Th.U. net gas, containing 35·5 p.ct. of blue water gas, gives 37 candles per 1000 B.Th.U. supplied, which is an inappreciable drop from the result with the coal gas 100 B.Th.U. higher. Then we get an equality within half a candle between 409 B.Th.U. net gas (containing 51·8 p.ct. of blue water gas) and the 347 net Uddingston gas (62 B.Th.U. lower)—the relative figures being 34·5 and 34 candles per 1000 B.Th.U. sold. These figures are remarkable and instructive. Up to a point the mixed gas gives a higher candle result per 1000 B.Th.U. supplied than the straight richer coal gas. The advantages to the consumers are readily seen. The first is mentioned in the report. It is that, with gas of the higher calorific power, the maximum candle power can only be obtained with a degree of care in the choice and adjustment of burner which cannot be regarded as generally exercisable; but with the lower calorific value gas, the maximum efficiency is more easily and consistently obtained, which is a distinct benefit to consumers who do not trouble much about the manipulation of their burners to realize the highest value from them. The second point is that lower calorific power gas can be made at less cost than the higher grade straight coal gas, and so be sold more cheaply per unit of B.Th.U. There is also the coal conservation point, which is a national advantage.

Before leaving this question of burners, there are two or three other points to be made. The first is that in the Uddingston investigation the inverted burners employed were only tested on the horizontal plane; and not at different angles to ascertain the average illuminating power below the horizontal plane, which would give a higher reading. There are photometers available which enable this to be done; and it is a pity that the Committee did not avail themselves of the services of one. The result is that for the inverted burners the readings on the horizontal plane are low; and therefore the thermal efficiency on the candle-hour basis is short of the actual. In the boiling-burner tests, if comparison be made between the thermal efficiencies of open-ring burners and those on the tops of gas-ovens, with heat-intercepting and heat-conducting bars across the flames, it will be seen that the efficiencies of the latter are materially lower, which is confirmation of previous findings in other quarters that the grids over the burners on hot-plates should be so constructed as to leave the burner-flames free from all disturbance and heat interception. With present-day burners, it is necessary, too, with the lower-grade gases to open-out the nipples, to obtain an adequate supply and prevent lighting-back.

The further tests with inerts are also valuable, as they prove that, providing the CO_2 is not high for purposes in which flame temperature is important, the consumer purchasing B.Th.U. is well protected. It is the maker of the gas who suffers most in having to provide in his plant and distribution system for dealing with a volume of inerts for which he will not receive a penny on the B.Th.U. basis. Works and distribution economy and revenue are both served by the supply of a diluent with a low percentage of inerts in it, such as can be obtained by steaming—as in the Uddingston case, where the inerts only total to 12·8 p.ct.—or by separately made water-gas. Touching steaming, there is a point that it is well worth while to bring out from the report prepared by Mr. J. G. Taplay and Mr. B. R. Parkinson on the "Internal Corrosion of Mains and Services." Chemically, hydrocyanic acid is the primary agent of corrosion, and the prejudicial effects of it are much increased by the presence of oxygen. In the presence of steam and incandescent coke, hydrocyanic acid is converted into ammonia; and ammonia can be removed from the gas by thorough washing. Conversely, ammonia in the absence of steam is converted into hydrocyanic acid by passing over red-hot coke. These are facts which should be added to the list of advantages derivable from the steaming process. The former and the present reports of the Gas-Meter Research Committee should be taken as supplementary to the reports of the Gas Investigation Committee.

A *précis* of the report of the Investigation Committee, with some further notes, is given in our "Review of the Proceedings," so that here we will not further comment upon it. Though it gives openings for criticism on points of detail and procedure, the report is a highly valuable one. Upon its lessons we congratulate Prof. Cobb and Mr. James W. Wood, the Research Chemist; and later on we shall welcome the results of the investigating work of Dr. Parker into the comparative economies of gas-producing systems. He has started work at Uddingston, where Mr. Lawrence Hislop finds that it pays both his Company and the consumers to produce and use gas of a calorific power of approximately 400 B.Th.U.

Coal Situation and Gas Standards Question.

A LETTER was read from Sir Evan Jones, the Coal Controller, at the meeting of the Institution last week, regarding the position of coal stocks and the question of future deliveries. We are afraid that the communication did not, whatever its original motive, do anything to ease the minds of men who have long been suffering great tension, and who are serving public supply undertakings depending upon coal as the raw material. On the contrary, the letter created alarm. It told us how the average stocks of coal at gas-works at a time of the year when they should, in the ordinary course of things, be fast rising, are only gradually improving; and the "improvement" is reflected by the possession of an average of three weeks' stocks in Greater London and two-and-a-half weeks' stocks in Provincial gas-works. These are averages. The men from the Provinces shifted uneasily in their seats as they heard the figures. Who are the fortunate ones who have more than two-and-a-half weeks' stock, while so many of them are below the reported average? The possession of the average, if it were general, would be something, though falling far below the pre-war normal level, and a level which provides a margin of safety over and above what is necessary to meet the seasonal vacillations of gas demand for light, heat, and power.

The outlook for supplies is anything but cheerful. All the hopes that were being encouraged with the return of miners from the front are sinking. There are many more men working now, all getting more money, and from July 16 they are going to work less hours. Before the reduced hours come into operation, we have Sir Auckland Geddes, the new President of the Board of Trade, speaking in the House of output reductions, and the Coal Controller sending hopes back to zero, both in relation to the current position and the factors that have to be considered in relation to the future. Sir Evan's letter gave the opportunity for the question referred to in our first editorial article last week being raised at the meeting—that is, the question as to the industry being thrown-back to the old standards by the efflux of the period which the Board of Trade tentatively named as the one during which the 450 B.Th.U. standard should be continued, and pre-existing standards—illuminating and calorific—be suppressed. Among the factors which the Coal Controller thinks may influence the supply of coal are the less working hours of the miners, the withdrawal of the Fuel and Lighting Order, and the ending of the protection given as to gas standards. The outlook for the gas industry is far worse now than it was some six months ago. Costs are higher for it; and prospects of coal supplies are dreary in the extreme. The indications of the Coal Controller himself are that immediate events may make the position worse, and one of those possible events is the supersession of the current calorific standard by the old ones. This is easily avoidable by the Coal Controller, though the shortening of the hours of the miners is not, and the public are clamouring for a renewal of freedom in regard to lighting and heating, and there will be considerable public indignation if another winter has to be faced with light and heat rationed. To retrace steps now

to the old gas standards, in view of the economic position of the industry, in view of the situation of coal supplies and the need for coal conservation, and in view of the requirement of the public for still more labour-saving B.Th.U. would be altogether reactionary. The industry cannot, and must not, contemplate anything of the kind. The war period has proved that there is an appreciable economy from all points of view in the utilization of blue water gas and charge steaming; and to strip the industry of such economy would be to the detriment of the coal situation, and to the gas consumer, for high as the price of gas is to-day, it must be higher if the old standards are re-established. The justification for the attitude of the industry is found in the report of the Board of Fuel Research, and in recently issued reports, papers, Cantor Lectures, and articles by men of position and high qualification in this particular matter.

It was urged in the "Journal" last week that the question should be raised as one of emergency at the meeting of the Institution. The Coal Controller's communication gave the opportunity for the passing of a resolution, on the proposition of Mr. S. Tagg, which will strengthen the hands of the National Gas Council in moving through the Coal Controller. The Council, we believe, had already been in consultation with him; but the expression of feeling in a full meeting of the Institution representing gas interests throughout the country will be of immense service to them in their further discussions. Meantime, it is well to note, in connection with applications for calorific standards, that the authorities will not at present budge from 500 B.Th.U., on the ground that they have no power to do so until there has been legislation upon the report of the Board of Fuel Research. This is seen from the remarks of Mr. D. T. Livesey at the meeting, in which he related his recent experience, and the refusal of the Board of Trade to adopt even one of the figures named by Sir George Beilby and his colleagues—466 B.Th.U. There is no General Act that commands the prescription of 500 B.Th.U. Such established position as the standard has is only due to precedent. Select Committees and the Board of Trade are at liberty to depart from it if circumstances warrant; and never did circumstances justify departure more than to-day. Never, too, has there been, from a competent source, stronger judgment in the possession of the Board of Trade than it has now, which declares that a statutorily fixed standard for all gas from all coals and in all circumstances is economically unsound, and therefore wrong.

Increased Depreciation Allowance for Income-Tax.

With reference to the editorial article on this subject last week, Mr. E. S. London, the Deputy Chief Inspector of the Inland Revenue Department at Somerset House, in reply to an inquiry, confirms the granting of an additional allowance of 50 p.ct. upon existing rates to meet abnormal conditions due to the war. This applies to gas undertakings other than those owned by municipal authorities and other public bodies. The arrangement is to take effect: (*a*) For income-tax 1918-19 and 1919-20. (*b*) For excess profits duty for all accounting periods at 60 p.ct. and upwards. If the income-tax for 1918-19 has been paid, the appropriate additional allowance may be added to that for 1919-20. The allowance for excess profits duty purposes is to be made as far as possible against the assessment for any accounting period now open.

Oil in England.

The fact has had world-wide publicity that oil has been struck at the Hardstoft well—one of the seven that are being sunk in Derbyshire; but the event should be placed on record here, as oil is a competitor of the gas industry, and at the same time a commodity of which it uses a large quantity. Two more wells have been started in Staffordshire; and preparations are being made for drillings to the south-east of Edinburgh. The first shows of oil were accompanied by gas; but the greatest quantities of gas have been met with, so it is reported, in the Renishaw No. 1 well, where the flow at one time was estimated at 200,000 to 300,000 c.ft. per day. However, as to the Hardstoft well, the rise of oil in the casing has been at such remarkable speed that drilling has for the time had to be suspended so that the oil shall not be wasted. Samples have been tested; and it is stated to be a clean oil of good quality. So far the find is highly satisfactory; but while all hope in the country's interests that the most sanguine expectations will be fulfilled, too much confidence must not be founded upon early results. All that can be said at present is that they are encouraging.

Benzol Power Tests.

American motor men are interesting themselves in benzol. The Technical Committee of the American Automobile Club have been inquiring into its use, and have discovered what has long been known here, that there is more power in benzol than in petrol. The reason for the great increase in brake horse power is believed to be that benzol vaporizes more easily, and that a mixture of benzol vapour and air burns completely, and leaves very little carbon residue. The tests that were carried out showed that as speed increased so did the increase of power over petrol. At 2000 R.P.M. the increase was 18 p.ct., at 1400 R.P.M. it was 9·3 p.ct., and at 800 R.P.M. it was 2 p.ct. The fuel consumption indicated a decided decrease compared with petrol between 930 and 1800 R.P.M. Above the latter speed, the decrease became less and less, and below 930 R.P.M., the fuel consumption rapidly increased. The engine was also run for a period of 4¾ hours on benzol at an average speed of 1077 R.P.M., during which run it developed an average B.H.P. of 25·9. It consumed 13·2 gallons of fuel, which is at the rate of 2·78 gallons per hour, or 0·107 gallon per B.H.P.-hour. This corresponds to a decrease in fuel consumption of 12·3 p.ct. as compared with petrol. Subsequent examination showed that the pistons were practically clean at the centre; there being little oil carbon around the edges. There was a little carbon on the valve caps; but this was of such a texture that it could be easily removed. A test with 90 p.ct. benzol showed that it was capable of giving a greater B.H.P. throughout the speed range of the engine than was obtainable with commercial petrol. The increase varied from approximately 4·4 p.ct. at 800 R.P.M. to 19·4 p.ct. at 2000 R.P.M. Above 930 R.P.M. the fuel consumption with benzol was less.

Eliminating Radiation Losses in Water Boiling.

Attention was called by Mr. J. Weaver Smith, in a paper which he read at the meeting of the Indiana Gas Association, to an internal method of boiling large quantities of water, caustic soda solution, &c., which he said produces an efficiency of 95 p.ct. In one installation, cited by him, he said they were able to boil 68 gallons, or 566 lbs., of caustic soda solution in about 58 min., with a gas consumption of about 155 c.ft. Before making this installation, it required from two to three hours, with a gas consumption more than double, to do the same work by means of burners underneath the tank. One of the good features of the process is the low cost of installation. The one just alluded to cost the consumer less than $20, not including the tank or the necessary blower. Reckoning another $20 for the tank and $35 for the blower, makes a total of $75, as against approximately $150 for a tank equipped with pipe-burners underneath. It was explained by the author that the arrangement consists in placing a zig-zag coil of iron pipe on the bottom and inside of the tank, one end passing through the side of the tank in a horizontal position. The other end of the coil comes up in a corner to a point a few inches above the top of the tank. About ½ to ¾ in. from the lower end of the coil, and in a line with it, and pointing directly into it, is placed a suitable blast-burner. This burner is directly connected by means of a cock and mixing tee to the air and gas supply; air being supplied by a positive pressure blower. The flame from the burner goes at once into the coil; and the heat from it is dissipated through the coil into the liquid to be heated. The stack loss is very low, owing to the large amount of heating surface, and there is practically no loss from radiation.

Standard of Calorific Power Act.—The Board of Trade have made Orders under the Act in favour of the Llanelly Gaslight Company and the Wolverhampton Gas Company. Applications to the Board have been made by the Aldershot Gas and Water Company and the Alliance and Dublin Consumers' Gas Company.

Municipal Ownership in Missouri.—A proposed amendment to the Missouri Constitution, giving municipalities of more than 75,000 population the right to acquire gas plants and other public utilities "by purchase, condemnation, or construction," has been engrossed in the State Senate. The measure provides for the issuing of securities in a manner intended to encourage municipal ownership of utilities in Missouri.

Statutory Undertakings (Temporary Increase of Charges) Act.—Applications to the Board of Trade for Orders under the abovementioned Act have been made by the Bognor Gaslight and Coke Company, the Denbigh Water Company, the East Kent District Water Company, the Titchfield District Gas Company, and the Wadhurst and District Gas Company. The Local Government Board have issued an Order under the Act raising the price of gas from 5s. per 1000 c.ft. by 2s. 6d.—making the charge not to exceed 7s. 6d. per 1000 c.ft.—in the district of the Tyldesley-with-Shakerley Urban District Council.

THE INSTITUTION OF GAS ENGINEERS.

PROCEEDINGS AT THE ANNUAL GENERAL MEETING,

HELD AT THE

INSTITUTION OF CIVIL ENGINEERS, LONDON,

MAY 27, 28, and 29, 1919.

President: Mr. SAMUEL GLOVER, M.Inst.C.E.

REVIEW OF THE PROCEEDINGS.

[For full Report see p. 573.]

OLD times have come again, but with some changes. As we foregathered in the spacious entrance hall of the Institution of Civil Engineers last Tuesday, faces old and new were seen; and the density of men there (with a few ladies) foretold of a lecture theatre that would be packed as soon as—or as it happened soon after—the President was in the chair. By the way, it would be a better compliment to the President, if members would take their seats before he takes the chair, and not wait until he is in the chair before making an appearance. This causes delay; and it did so on this occasion, and necessitated a good many appeals from the President to members to come forward, and utilize vacant seats in front, rather than stand and block-up the gangways round about the main door leading into the theatre. However, we were saying that old times have come again, and that there were faces old and faces new. The old times had representation in numbers—numbers that approximated to those of pre-war days. But as every day brings some change, the five years that have passed since we met in days unclouded by warfare have left their marks on the ranks of members. Many there were who were with us then who are not here to-day. Their professional places are filled by other men. Those who were with us then, and are with us now, have passed through five strenuous years. But the experiences of these years have broadened their outlook and have heightened their ambitions. They are looking upon the industry now—upon its potentialities, and upon its scope for service—with different eyes and different intelligence from what they were doing before the war-torn quinquennium. The Presidential Address, the reports of the Investigating Committees, the papers, the discussions all breathed of a fresh life—fresh work, fresh thoughts, fresh methods, though the way is paved with difficulty, which has to be passed.

The President (Mr. Samuel Glover, M.Inst.C.E., of St. Helens) is in the chair. He has with him the Vice-Presidents (Mr. Thomas Goulden and Mr. Thomas Hardie), the Hon. Secretary (Mr. W. E. Price), the Secretary, Mr. Walter T. Dunn, and the members of the Council are there ranged to his right and left hand sides apparently in full number. Just before him in the front seat with the ordinary members is Sir Dugald Clerk, the then President-Designate; and not far away are seen his two collaborators in the preparation of the case of the industry on coal conservation—Prof. Arthur Smithells and Prof. John W. Cobb. After a little delay, there was not a vacant seat in the vast threatre, which told of an easing of the times, and the ardent interest of the gas profession in the problems that have to be solved before the industry can go forward with freedom, and under conditions which will re-establish it, and enable it to render a still larger and still more vigorous and generous service in the national interests. We think it is safe to say that, in point of numbers, this was a record meeting.

Preliminary Business.

When all were seated, the President greeted the members with a hearty welcome. The minutes of last year's meetings were taken as read. Mr. C. Valon Bennett, of Rochester, and Mr. R. Beynon, of Torquay, were appointed Scrutineers of the ballot papers, and were soon engrossed in their work elsewhere.

Visitors from Overseas.

Major Strange (a member of the American Gas Association) was present, and was greeted by the President as an "ally in gas and in war." There was also Mr. T. O. Morland from Sydney (N.S.W.) with his brother, Mr. W. S. Morland, of Gloucester. To both gentlemen, the members gave a very warm welcome. Mr. J. N. Reeson, of Melbourne, was also expected, but was not present at the opening of the proceedings.

The President's Address.

The President was business-like. He soon gave evidence that he was going to have all the value possible out of the time allotted to the meetings. He was at once on his feet, address in hand. It was published *in extenso* in our pages a week ago; and a comment upon it appears in earlier columns to-day. Therefore the briefest reference will suffice here. It was delivered in clear tones which reached every part of the lecture theatre; and it was punctuated with that emphasis which print alone cannot give to it, but which gave due expression to the author's intentions and meaning. One cannot put the same spirit nor even convey the same meaning to words as an author himself can do, if he has the voice. The address marks a stage in the industry's history; and it is a thousand pities for the industry that much of the deliverance will not have a larger public reading than its circulation within the industry will accord it. We heard of the rough storms which the industry has encountered; we heard of the excellent work that, despite all, has been done by it for the nation. There was the appeal to bring lessons and practical experience to bear to repair the mischief that has been done, and to shape our course to the larger sphere of action and prosperity that await the industry—if there is no blundering. It is of this we have to beware, and upon which we have to concentrate energy and action. Optimism is part of the President's nature. He is satisfied with the National Gas Council, which has before it a great opportunity for proving its use. He has no sympathy with those who whine about the pity of it that the Institution does not now represent the industry as a whole. It never did, and never could. Technical work constitutes its sphere; and technical work, pre-eminent as it is, does not constitute the whole interests of the

industry. In the technical sphere, the Institution can have a fuller life by reason of the existence of the National Gas Council.

Statistics were given which show the great importance of the gas industry as utilizers of capital, and as the suppliers of a necessity to millions of the inhabitants of the country. Carbonizing in the industry about 20 million tons of coal a year, improvements in process which will enable a reduction of this consumption is a national benefit; and the Legislature should see to it that it does not place further obstacles in the way of achieving so desirable an end, and that it removes those already existing. Later in the address the President showed that if to-day the industry was only producing an average of 10,000 c.ft. of gas per ton, some 7 million tons more coal would have been needed last year. This is a point for our Legislators to ponder in conjunction with the claims of the industry, which are directed to a further reduction of the quantity of coal carbonized per any given unit of thermal value sent into the gas-mains. The President urged, too, that better results and greater economies could be brought to book if clean coal were supplied to the gas industry; but it is clear that he is not indulging in too high hopes regarding the coal situation next winter. In view of the material, if not financial, productivity to the industry of a ton of coal, the Coal Controller should make an effort to ensure that gas undertakings are well supplied with (this is most important to productivity) suitable coal. But we are here outpacing the President by running from the sequence of the address. From the "Journal" he quoted figures as to the contributions by the industry of materials for explosives during the war, supplementing the data with figures of his own.

There was indication as to the clumsy and distorted character of the legislation of the past; and as an appendix to the address there appears a useful summary of the laws under which the industry has been compelled to operate. We will not condemn the legislation as not fitting the conditions and knowledge of the period at which it was passed; but it does not say much for the Legislature or for the industry that this legislation or the petrified rule that has issued from it is placed upon the gas industry in this twentieth century, with its changed conditions and knowledge. To use the words of the President, "the greatness of the reformation called for can only be realized after the shortcomings of the past are recognized in the light of a newly awakened spirit." Liberty and adequate financial recompense for capital employed and service rendered must be granted if the industry is to have its strength renewed, and yield service to the utmost of its power. We heard of the exacting duties to be performed, and the operations to be controlled by the gas engineer, and of the pressing need for investigation—all of which touches upon the question of the higher standard of training for the gas engineer, a subject of which we were to hear more on the morrow. The refractory materials research received comment, and so did the subject of condensation; and reference to the production of ammonia compounds led to a criticism of the parsimony of some directors and committeemen in spending upon plant and apparatus which would make works—particularly small ones—more profitable than they are. There were suggestions as to lines of thought and work. The President would like to have extracted from all the knowledge that exists on the subject of purifying plant, the ideal model for a purifying-house; and he submits to "the brainy men" of the industry the problem of providing an economical process for the production of a suitable quality of oxygen gas for use on gas-works. "The brainy men of the industry!" Why does not the President himself tackle the problem? We were carried on step by step to the consideration of steel, sulphate stills, tar-distilling works, the housing schemes, and industrial gas. In the President's view, coke-oven gas, whenever it can be spared at the ovens, should be utilized by any adjacent public gas-supply authorities, if it is made commercially possible to use it. But what above all else does the industry want—men. "There is great need for men of courage and right vision to guide the industry to its rightful position in the service and confidence of the nation." "The time demands strong minds, great hearts, true faith, and willing hands."

There was no high-flown diction in the address; it was the plain statement from a practical head, with an abounding faith that the generous results of the industry's work must win-through. This was the assessment that we recognized in the applause that followed the address, and for which the President was thanked by the words and motion of Mr. A. E. Broadberry, seconded by Mr. John Young, and the further acclamation of the members generally.

Coal Position, and Re-imposition of Old Standards.

There was a message for the members from the Coal Controller (Sir Evan Jones), which they would have liked to have found more definite and promising. His official information is that stocks at gas-works are improving, though slowly. On May 9, the gas-works in Greater London held stocks averaging three weeks' of maximum consumption based on December last; and for provincial gas-works the average was two-and-a-half weeks. These are "averages" be it marked; and they are terribly low for a time when accumulation is customary. Sir Evan foresees factors which may tend to a reduction of available supplies—the lowering of the miners' working hours, the possible withdrawal of fuel and lighting rationing, and the withdrawal of the existing calorific standard. These factors do not work in sympathy one with the other; and at least one of them is avoidable. If there is the possibility of the reduction of coal output, then it would be sheer folly to reinstate the old standards in the gas industry, and national economy and assistance to the industry, by maintaining conditions which will tend to obviate things going from bad to worse for it, demand that the old standards should not again be allowed to drag at its wheels. The report of the Board of Fuel Research should safeguard the industry from any such error. The members were rightly alarmed at the prospect hinted at in the communication; and Mr. S. Tagg moved a resolution urging the Council to make representations to the Board of Trade and the Coal Controller as to the injury that would result from the withdrawal of the present calorific conditions at the end of June. The proposal was seconded by Mr. J. P. Leather. Both the President and Mr. R. G. Shadbolt were averse to any indication being made that the members entertained in their minds any possibility as to the relief being withdrawn, seeing that the withdrawal would curb all progress, and limit all reconstruction. But Mr. D. T. Livesey, of East Grinstead, has been negotiating for a calorific standard; and 500 B.Th.U. is being insisted upon, on the ground that nothing can be done on the report of the Board of Fuel Research—not even a 466 B.Th.U. standard will be granted—until an Act of Parliament authorizes something different from the 500 B.Th.U. one. There is the danger then of the industry being recommitted to the observance of old standards, which would mean further confusion for it. The least the authorities should do is to deal with this matter from a sensible point of view. They have the power; and to exercise power to do harm ought not to be among their functions. However, the resolution was modified so as not to impart the false impression that the industry contemplates that the authorities will take a step that is opposed to commonsense, to right, and to the nation's interests.

Demobilized Men and Pre-War Conditions and Salaries.

The annual report was presented and its adoption moved by the President, and seconded by Mr. Thomas Goulden. Opportunity was taken by Captain Staley to call attention to the injustice that some undertakings are trying to inflict upon discharged active service men through the terms of their reinstatement. He did not allege that this was being done generally; and we are thankful to say that such an allegation, if made, would have been a slander on the major part of the administrative men of the industry. Light was thrown upon the matter by Mr. R. G. Shadbolt, who is Chairman of the Demobilization Committee of the Institution, when he said that Captain Staley had been offered reinstatement at only his pre-war rate of remuneration, though conditions have so much changed. The sympathy of the meeting was clearly on the side of Captain Staley; and we hope the matter will be looked into by the Council, though unfortunately they have no power to do anything—not even to pillory gas administrations without running risks—beyond pleading for justice being done to men who have been serving their country.

Gas Investigation Committee's Report.

This was one of the chief features of the meeting. The Chairman of the Committee (Prof. Arthur Smithells) introduced the report, and referred to the circumstances

under which the work is being carried on as having somewhat improved. An increase of the staff has been made possible through the cessation of hostilities, and other facilities have been obtained. At present the reports must be taken as rather a disclosure of the course of the inquiry than as being finished records. They must not be taken as representing anything definite or final. Prof. J. W. Cobb is the really responsible man in this matter; and there was an indication from him as to the vast ground which the inquiry covers. The more recent work has convinced him that the higher the calorific value of a gas is, the greater is the care needed in the construction and manipulation of the consuming appliances. Therefore the reverse, within reasonable limits, also stands good. There we have an argument for the close co-operation of the gas-maker and the maker of the appliances consuming the gas, which accords with the views of the Board of Fuel Research. Mr. James W. Wood, M.Sc., reviewed the report, which is an extensive document.

Gas of the Future, and Coal Conservation.

The report is something for study. The Gas Investigation Committee have in it hit the right nail on the head. Mr. J. W. Wood has continued his inquiry into the relative efficiencies in use of different grades of gas; and Dr. A. Parker has begun a research into the comparative economies of production—opening out at Uddingston, the vertical retorts at which Mr. Lawrence Hislop (who has been co-opted a member of the Committee) has placed at disposal for the purpose. The importance of coal conservation is spreading among scientists and industrial men; and the occupants of the political land have interested themselves in it, and, responding to their traditional mode of action, they have obstinately taken the wrong turning. The gas industry is partly to blame. It has allowed political precedent to override persistence in prominently showing what it can do in this line. The efficiency of gas-works carbonizing processes is already great; and the report of the Committee tells us we must miss no opportunity of realizing further economy. Not only this, but we must miss no opportunity of transferring from the solid material into gaseous form all the B.Th.U. that, according to the manner of their provision, can be conveniently dealt with by consumers' appliances. To this end, the Committee tell us what is already well known. Gasification of coke as water gas inside the retort or in separate generators is a simple means to this end. "If blue water gas," they add, "is made separately, no more is demanded than an extension of what is already practised in many gas-works with the modification, which is really a simplification, that carburetting is not essential." This depends on whether there is stripping of the coal gas; if so, the gas-meter and main and service investigators tell us in their reports for this and last year, that a little carburetting is a preventative of trouble with metal pipes and parts and the diaphragms of gas-meters. Steaming of retorts has beneficial effects upon the volatile products other than the gas, as the published accounts of results amply disclose. We are promised from the Uddingston investigation a thermal and chemical balance-sheet, which will be highly important.

The Character of the Uddingston Gas.

The tests at Uddingston have been made on a washed gas of approximately 400 B.Th.U. (actual 388 gross, and 345 net); and the results clearly indicate—to put the matter broadly—that such a gas (which is obtained by heavily steaming the vertical retort charges) can be used with good efficiency in both low and high temperature appliances, when the simplest modification of the burners tested is made by enlarging their orifices. The report includes other tests made at Birmingham; but the use of the 400 B.Th.U. Uddingston gas first claims consideration. It is a gas containing 12·8 p.ct. of inerts, and only 12·2 p.ct. of methane. The volume of air required by it is only 3·1 c.ft. per cubic foot of gas; so the B.Th.U. per cubic foot of self-combustible mixture is 94·6 B.Th.U. gross.

Ring-Burner Tests.

The same burners were used in the ring-burner tests with the Uddingston gas as were described in the first report. But the nipples had to be broached-out. Then the flames could be turned quite low without lighting-back. The water-containing vessel in tests made with the No. 2 burner was raised 1·75 in. above the burner to attain satisfactory working conditions. The efficiency obtained on the net calorific value ran from 56·2 to 60 p.ct.; and the time occupied in raising 1 quart of water from 60° to 212° Fahr. (calculated from the boiling of 8 lbs. of water) ranged from 3·6 to 4·6 minutes. The average figures for all grades of gas in the first report were 56 p.ct. for burner No. 1, and about 60 p.ct. for burner No. 2. This shows that the same thermal efficiencies can be obtained with the 388 B.Th.U. gas gross as with the other calorific value gases.

Some tests with cooker hot-plate burners suggest the wastefulness of having heat-dispersing, flame-interfering bars over the top. The average thermal efficiency obtained was only from 41 to 42 p.ct. of the net calorific value (345 B.Th.U.); and the time taken to do the work was longer. The full details will be found in the report. Generally, the ring-burner results prove that the value of different gases for this use is directly proportional to the potential heat units they carry. But—this appears to us to be a most important point—a comparison of the Birmingham and the Uddingston results indicates that, probably on account of the composition and mode of combustion of the Uddingston gas, a given burner may be worked at a rather greater B.Th.U. rate on the gas of lower calorific value than on the higher without loss of thermal efficiency. The flames are somewhat shorter, and do not smother so readily. Remember this is gas of which Mr. Hislop is [*ante* p. 503] selling 22,472 c.ft. per ton of coal carbonized.

Upright Incandescent Burner Tests.

In these tests, it was also necessary to open-out the nipples. The first burner used was a simple incandescent upright one; and the maximum thermal efficiency was obtained at 65 candles, with a consumption of 5·48 c.ft. per hour, and a pressure of 16-10ths. The thermal efficiency was 29·3 B.Th.U. net per candle-power-hour. The illuminating power was carried higher, but at the expense of efficiency. The thermal efficiency of 29·3 B.Th.U. net per candle-hour is better than the best value given in the first report—viz., 33 B.Th.U. net per candle-hour. But the latter figure was obtained without the use of a chimney; and for the purpose of comparison (a plain chimney having been used in the Uddingston test) 24 to 25 B.Th.U. per candle-hour should be taken for comparison with the 29·3. An advantage with the lower-grade gas is that it does not require the same degree of care in the choice and adjustment of burner. The chimney has an important effect; a typical test at the same consumption being 69 c.p. with chimney, and 48 c.p. without. We will pass over the other upright burner tests, as they are simply confirmatory of the conclusions already noted. They also prove that, under suitable conditions, gas of low calorific value is capable of yielding very high candle powers. The main point to be noted is that nipple orifices must be modified to enable the delivery of the necessary B.Th.U. without excessive pressure; otherwise trouble ensues, with aeration and lighting-back.

Inverted Burner Tests.

The tests with inverted burners are vitiated by the fact that the photometric measurements were only carried out on the horizontal plane; and every experimenter (the report mentions the point) knows that the maximum illuminating power with an inverted mantle is not obtained in the horizontal direction. Moreover with different constructions of burner, the angle of maximum illumination varies; and therefore, with different burners, though all the other conditions—consumption, pressure, and so forth—may be equal, there is no consistency between the illuminations obtained on the horizontal level. The results cannot therefore be taken as representing the maximum illuminating values, or the efficiencies of inverted burners as compared with upright ones. Unless maximum performance is known, actual efficiency on the thermal basis per candle-hour cannot be determined. The results have really little value beyond showing what the burners will do relatively one to the other, on the horizontal, at different consumptions and pressures. The mantles (with the exception of a large regenerative lamp) were all tested bare. In the different tests, we get efficiencies with different burners of 36·2 B.Th.U. per candle-hour, 27·7, 31·2, 30·5, 35·2*, 27·1*, 25·3*. [The three starred figures are for a high-power low-pressure lamp tested, in the order of the figures, bare, with cylindrical shade, and outer globe in addition to shade.] Commenting

on the tests, the investigators say that, if we take into account the fact that the measurements were made in a horizontal direction (which does not represent the maximum candle-power for the inverted burner), and that no chimneys were used, this would, in all probability, make the thermal efficiency of the inverted burner slightly greater than that of the upright. The fact is also commented upon that using the low calorific power gas "with the incandescent burner (taken as representing the most stringent requirements of high-temperature domestic use), the maximum efficiency under test conditions is a little lower than the best obtainable with gas of a higher calorific value, but is much more easily and consistently obtained."

Mixtures of Gas with Blue Water Gas.

The investigation as to relative efficiencies in use of mixtures of straight coal gas from horizontal retorts without stripping, with different percentages of blue water gas has also been continued in Birmingham. In the earlier tests no chimney was used with the upright incandescent burner (No. 1); but these tests clearly demonstrate that, by the use of the chimney, the thermal efficiency is improved by from 20 to 25 p.ct. The specific gravity of the gas mixtures used ranges between ·44 to ·49. Had the calorific value been reduced to the same extent (viz., to 450 B.Th.U. gross) by the introduction of inerts, the specific gravity would have risen to at least ·60. There is a notable difference in the air requirements per cubic foot of mixed gas; but the quantities are related to one another in such a manner that the value in heat units available per cubic foot of (theoretical) gas-air mixture is constant within 2 p.ct. Table XXXIV. shows this. Taking the gross figures, and putting the net in parentheses, the coal gas has a calorific value of 618 (556) B.Th.U.; the volume of air required per cubic foot is 5·47; and the B.Th.U. per cubic foot of mixture are 95·6 gross. With 13 p.ct. of water gas, the corresponding figures are: 572 (516), 4·99, 95·6; with 23·8 p.ct. of water gas, 541 (486), 4·68, 95·3; with 35·5 p.ct. of water gas, 506 (455), 4·33, 94·9; with 51·8 p.ct. of water gas, 453 (409), 3·81, 94·4. Thus it is seen how, through the reduction of the quantity of air required as the amount of water gas ascends and the calorific value of the mixture descends, the B.Th.U. per cubic foot of the mixture retain an almost identical level. Thus there is no reason for expecting that one mixture will give better results than another, provided always that the apparatus in use will permit the generating of heat units at the same rate. Any differences that are observed may be accounted for by size and shape of flame, manner and rate of combustion, and the extent to which the actual mixture conditions at the burner head approximate to the theoretical indicated in Table XXXIV.

The burner used in this series of tests was No. 2, without any alteration; but the investigators admit that completely satisfactory comparison of the different gases can only be made when each is permitted to exercise its maximum duty in an appliance properly adapted to its use. On this factor in the situation, the Uddingston tests form an instructive commentary, indicating as they do the extent of the benefits resulting from a simple enlargement of the nipple orifice on the one hand, and a careful choice of burner on the other. Returning to Birmingham, and to the tests now under notice, with the 556 B.Th.U. net straight coal gas, and 2200 B.Th.U. supplied per hour, the illuminating power was 38·2 candles per 1000 B.Th.U. net; the 516 B.Th.U. net mixed gas, 41·5 candles; the 486 B.Th.U. net mixed gas, 38·3 candles; the 455 B.Th.U. net mixed gas (supplying 2000 B.Th.U. per hour), 37 candles; and the 409 B.Th.U. net mixed gas (2200 B.Th.U. per hour), 34·5 candles. Compare these figures for mixed gas with the straight coal gas, and the advantage to the lighting consumer will be seen. Without steaming 423 B.Th.U. net Uddingston gas (2100 B.Th.U. per hour) gave 33·1 candles per 1000 B.Th.U.; and with steaming the 347 B.Th.U. net gas gave (1800 B.Th.U. per hour) 34 candles per 1000 B.Th.U. net.

A Supplementary Statement on Inerts.

Supplementing the report, Mr. Wood referred generally to some tests which he had been instructed to make as to the influence of the adulteration of a straight coal gas with nitrogen at different stages. A straight coal gas was made of 625 B.Th.U. gross; and it was reduced to different levels of calorific value by nitrogen until 450 B.Th.U. was reached. Full details will be published later on; but meanwhile Mr. Wood states generally that the mixtures so obtained showed no differences of any practical importance either of attainable candle power or thermal efficiency. The only modification made to the upright burner used was the opening-out of the nipple.

Indefiniteness and Inerts.

In the discussion, the Committee were not allowed to go free from criticism. In the opinion of some critics, the Committee would have done better to have refrained from publishing the results of tests until they had reached a perfect state in the mode of carrying them out. A reason for this objection was voiced by Mr. Jacques Abady—that there is a danger of people drawing deductions from the figures, and only half-reading the body of the report, and this when the Fuel Research Board have adumbrated what should be the Government policy in regard to gas supply. Given a proper vehicle for the consumption of gas, there is no difference in the thermal efficiency which a consumer obtains at different calorific powers; but Table XL. seems to show that more B.Th.U. are required to do certain work as the calorific power drops. Mr. Abady would like this table to be expunged from the report; but Prof. Cobb resents this, as the report itself in his opinion fully explains any discrepancy between the figures, and the conclusions drawn by the investigators. There was Dr. Davidson, too, strongly opposed to the omission of the table, as it represents the truth under the described conditions. And later on, on the same issue, we had Prof. Smithells pointing out that the investigation is taking a systematic line—using first consumers' appliances without modification; next consumers' appliances slightly modified for the lower calorific power gas; while the next stage will be with appliances designed specially to deal with the lower quality gases. There was submission by Dr. Davidson that one B.Th.U. is not as good as another; it depends upon the company it keeps. Flame temperature must be considered, particularly in relation to the CO_2 content. No practical man would for metal melting look at a gas which contains a large percentage of CO_2, as he would not get the temperature. There were remarks by Mr. Gaster, who thought that the lesson of the report was that appliances must be suitably designed to get as much as possible out of the gas.

Having experimented at Oldham for the past eighteen months, Mr. Tim Duxbury gives his assurance that the present quality of gas—410 to 420 B.Th.U.—is giving every satisfaction for lighting, heating, cooking, and power. By-the-by Mr. Abady had previously stated that the proposal of the Fuel Research Board to limit inerts to 12 p.ct. is a retrograde movement; and here we had Mr. Tim Duxbury recounting his experience with gases containing 14 p.ct. and 38 p.ct. of inerts. The increase to 38 p.ct. was chiefly air, which is not quite the same thing as diluting with pure inerts, seeing that dilution with air is only anticipating the mixture that must take place before combustion at the burner. As the full report of his speech shows, he claims a higher efficiency with boiler burners with the gas containing the higher percentage of inerts. Quite as good a light is obtained by its use in the street-lamps. He did not attempt to explain the reason. With the higher percentage of inerts, there has been less trouble with naphthalene. There was some reference by Captain Strange to experiments in America, which show that with different gases ranging between 1000 B.Th.U. down to 320 B.Th.U. per cubic foot, there is an approximate parity in the B.Th.U. per volume of mixture. It was pointed out by Mr. W. W. Townsend that certain fairly definite statements made by the Committee in the first report were destroyed by what appears in this one. Other speakers carried on the discussion. It was ascertained by Mr. H. E. Bloor that Sir George Beilby is fully conversant with the work the Committee are doing.

Sir Dugald Clerk, President.

Before the sitting closed on Tuesday, the result of the scrutiny of the ballot-papers was announced. There was great gratification over the election to the presidency of Sir Dugald Clerk, and recognition was made of the courtesy of Mr. Thomas Goulden and Mr. Thomas Hardie in remaining for another year in their existing offices in order to allow Sir Dugald to take the headship in this momentous year. The other elections and reappointments were also announced.

Benevolent Fund.

On Wednesday morning, judging by the number of subscribers present, very little interest was evinced in the

Benevolent Fund proceedings. This listlessness goes on from year to year; and it is inevitable there should be a discussion on the ways and means of increasing enthusiasm and subscriptions, so as to enlarge the power for good of the fund. Mr. C. F. Botley, Mr. D. T. Livesey, and Mr. S. Meunier were the principal speakers. The fact that, with the membership of the Institution, the subscriptions from members should amount to no more than £249 is not thought creditable. Ways were discussed by which more members might be stirred to contribute; and we heard from Mr. A. Masterton how in the North British Association the annual subscription includes a sum for benevolent purposes. We believe the amount is 2s. 6d.; and the only objection to this mode of collection is that those men who would give more are in effect limited by the settled sum. It was also suggested that the President should take an opportunity when there was a larger attendance of members of making an announcement on the subject. It is the non-subscribers and not the subscribers who want an earnest appeal poured into their ears.

Education of the Gas Engineer.

The war is over; and we are talking of the reconstruction of industry. Fresh foundations are being laid for that of gas manufacture and use. In the war period we have learned much. Latent properties of our industry have been revealed; and we see extended service resulting from their development. The claim upon the industry to do better is there; it is also appealing to its men from the midst of new and onerous financial conditions. The industry has to take its proper place in the new period of the world's work, which is to be carried on under freshly moulded conditions. This all means that the technical men of the industry will have placed upon them heavier responsibilities; and the technical men will appreciate that, as these responsibilities grow, their own ranks must be fed by young men whose standard of training must reach a level beyond that which has sufficed in the past. Improvement in plant, improvement in processes, extension of the scope of utilization, must be accompanied by the intellectual development of young men who show the necessary ability. All time has been opportune for the consideration of this question of the education of the gas engineer; the present time is more particularly opportune for action.

The Need of the Industry.

The subject was brought forward for discussion. The opening was entrusted to Prof. Arthur Smithells, than whom no better choice could have been made for the purpose; for the blending, through men, of science and practice has been with him a matter of perennial study through his professional career, in which he has done a good part in producing practical issue of the faith that is in him, and that is growing among men—so much so that other branches of engineering are doing what the gas industry has not yet effectively tried to do. What has been done by it has been little more than the opening of the ground. Prof. Smithells does not expect revolution in this matter; but he does want to see the educational problem earnestly attacked, and at least signs of a gradually extending appreciation of the value of bringing more science to bear upon our daily work. "We are at a period in the history of the gas industry when no effort must be spared to improve our efficiency;" and Prof. Smithells laid emphasis upon the "no." He asked us to "recognize clearly that there are two schools of education for industry—one is the works, the other the school or college, with its class room and laboratories." We cannot recognize the division indicated by the reference to "two schools of education for industry," in view of our opinion that education for industry is not complete until the pupil has passed through class room, laboratory, and works. The so-called two schools are merely the necessary changes in scene and opportunity to produce one result. The difficulty is that so many practical men still believe solely in the efficacy of experience on the works, and have definite views as to the futility of certain kinds of learning, and of the danger of the eager theorist. Even the practical man can over-estimate and under-estimate the value of the different components of a single "job." But fortunately for industry, fortunately for the country, the advocates of a higher standard of training for responsible positions in industry are making headway—slowly true, but surely.

A High Standard, and not Half-Measures.

Prof. Smithells does not despise self-education nor the evening school—all honour to the men taking hold of such advantages whose opportunities do not permit of utilizing higher provision. All the same, it is true that abundant examples may be seen in British industry of the insufficiency of self-education in science—cases where a knowledge of science and the power of using it have to some extent been acquired, but where want of the firm ground of a knowledge of basic principles is apt to lead men astray. The gas industry needs an accession to its ranks of men who are scientific masters of their profession. There is greater competition in front of the industry; and its responsible men will particularly mark the words: "The mechanical, civil, and electrical engineers feed their profession with a constant stream of recruits who have had three or four years' course at the University; and I feel certain that gas engineers should come into line. This will no doubt seem a large demand; but I am satisfied that nothing less will suffice." Most earnestly he entreated the members of the industry not to be beguiled by half-measures, but to make bold educational investments. The men selected for University training should, however, have real ability. The instilling of ideas and the developing of aptitudes cannot be done unless there is the receptive mind, and the latent intellectual power. The primary necessity of every human enterprise is to have educated leaders. Prof. Smithells also dealt with the controversial point as to whether the University training should precede or succeed works' training, or whether the sandwich system should be applied—University and works' training alternating. He has still an open mind on the subject. Different men, different treatment. But where the sandwich system cannot be applied, then we have a liking for a knowledge of principles preceding works' training, so that at this stage the pupil may appreciate the why and the wherefore of things that are done upon the works. The alphabet precedes spelling, writing, and composition. Principles should precede practice. At any rate, so it seems to us.

Views Must Change with the Times.

The discussion covered much ground. It was all highly interesting. But what has to be done by men now in position in the industry is not to view this question of training by the methods that were applied to themselves in years perhaps long past, but to view it in the light of new developments, and by peering, so far as their mental vision will allow them to do so, into the future to ascertain what will be the requirements. It is the only way by which men can revise ancient opinions on this particular subject. Developments should enable them to better gauge the requirements of training to-day for men who are to be the responsible gas engineers of the future than they themselves or those who thought for them were able to do some decades ago. So looking at the matter, we are inclined to say that one of the most practical and valuable speeches made was that by Mr. Percy Griffith, for it was at once a personal confession and a wise appreciation of need. A broad view is taken by Mr. H. E. Jones. He would have a gas engineer possess in the first place a mechanical training; he would have him when a pupil go to college to learn the principles of engineering; he would have him possess an elementary knowledge of chemistry. Mr. F. W. Goodenough was critical of the paper itself; and he got two or three points home at Prof. Smithell's expense. For instance, in regard to the author's references to the reluctance of parents to send their sons for a scientific training, and to the passive resistance of the students themselves, Mr. Goodenough blames the professors for not making the teaching more attractive. He also put the question to Prof. Smithells whether he is satisfied there is as much enthusiasm for and faith in industry on the part of the professors as they wish other people to have in men of science. Enthusiasm must be reciprocal. Mr. Percy Griffith went back thirty years, and spoke from his own experience of what was then considered sufficient training; and he held up an old edition of Molesworth and a more modern edition of Kempe to illustrate the difference between the state of knowledge then and now. In his student days practical training had supremacy; and he was cautioned against too much theory. But if men are now to be equal to the times, they must have theory and practice in correct proportions. The expression in the paper "the son of

his father" accounts for much, in Mr. J. P. Leather's opinion; because as the father was trained, so in all probability would be the son. He sketched what he thought should be the character of a gas engineer's education. We had Mr. S. B. Langlands, Mrs. Cloudesley Brereton, Mr. Thomas Hardie, Mr. D. T. Livesey, Mr. Alex. Wilson, Mr. Thomas Goulden all expressing their views. The obstacle of not having a long purse to minister to the needs of the ideal forms of training was pointed out; and as a natural consequence the good work every technical school does in giving opportunity was defended—specially by those from across the Border. There was some discussion as to the order in which the scientific part of the training should be taken; and the impression left upon the mind is that opinion was heaviest in favour of this being continued (where it could not be mingled with practical work) while the mind is disciplined to study. After schooldays, and when a few years have been spent on a works, there is less inclination to return to close studies.

A Message from France.

The President of the Société Technique de l'Industrie du Gaz sent a message congratulating the President and members on this their first meeting after victory; and it was decided to gratefully acknowledge the message and reciprocate the congratulations of our French confrères.

Crushing Strength of Fire-Bricks.

The report of the Refractory Materials Committee, which was presented by Mr. A. E. Broadberry, was, as usual, interesting, but in part inconclusive. There first fell from him acknowledgment of the services of his predecessor in the chair, Dr. Harold G. Colman; and there was welcome by him of Major Bywater, who he hoped would be able to resume at an early date his leadership in the work of the Committee. The report was in two parts—the first dealing with the crushing strength of fire-bricks, and the second with heat conductivity. The former was by Mr. W. Emery and Dr. J. W. Mellor; and the latter by Messrs. C. Edwards and A. Rigby and Dr. Mellor. There is a mixture of academical and practical interest in a knowledge of the crushing strength of fire-bricks. The knowledge is rendered of little more than academic value by the fact that usually the crushing strength is much higher than is required in practice; while the practical value is found in the information that crushing strength gives of the internal strength of the brick, and of how the binding agent is doing its work. The report gives an analysis of the clays from which were made the bricks which were tested; and the method of conducting the tests is that indicated in the standard specification. Generally the results (which are tabulated in the report) show that the crushing strength is reduced by increasing the grain-size of the grog when the proportion of grog is constant, and also by increasing the proportion of grog when the grain size is constant. Applying the load to the 4½-inch face of bricks gives a higher crushing strength than when the load is applied as directed in the standard specification—on the narrow side. As yet, there are insufficient data available to enable any conclusion to be drawn respecting a possible relationship between the so-called fusion temperature of the clay and the crushing strength of the cold bricks. There is probably a close connection between the temperature co-efficient of the vitrification and the crushing strength. It is further probable that the crushing strength reaches a maximum during the firing of the brick, and that the strength gradually deteriorates when the bricks are in use. It does not, however, follow that the crushing strength of the newly-fired brick is at its maximum. Tests described show that with some bricks subjected to repeated periodical heating, the crushing strength gradually rose to the maximum point, and then gradually fell. These bricks could not therefore have been turned out by the manufacturers at their maximum mechanical strength. The increase of the mechanical strength on heating in use indicates a continuation of the work of vitrification, which is supposed to have been nearly completed in the burning of the brick. The after-contraction or expansion of a fire-brick is due to these changes.

Heat Conductivity.

High heat conductivity is a very essential quality in gas-retorts and fire-bricks; and, in the second part of the report, this is dealt with. But as the calculations could not be finished in time for the meeting, these and the conclusions will have to be presented later. There has been abundant proof that the thermal conductivity of insulation materials at ordinary temperatures is greater the less porous the materials; and it has been assumed that the results apply also at high temperatures. Hence it is inferred that a low porosity is desirable in order to ensure a rapid passage of heat through a muffle or retort. Five years ago one of the authors at Manchester held a diametrically opposite view, and showed that the transmission of heat by radiation and convection has not been taken into account. This is the point to which theoretical consideration is devoted in this section of the report. But the calculations and conclusions must be awaited.

Casting Retorts.

This was a matter that was referred to last year by Mr. J. P. Leather; and now on this occasion there was a large sample of a section of retort that had been cast specially for the meeting. Mr. Broadberry referred to it. It was not a good sample; it had been hurried, and in firing it had come to grief. There were fire-cracks upon it, which was probably due to unequal heating in the desire to get the sample finished for the meeting. It is not known yet what is the opinion of Dr. Mellor upon the specimen; but it will be interesting to have it. One point mentioned by Mr. Leather is that the cost of the casting process is not so great as was anticipated. This is a matter for satisfaction, if successful retorts can be produced; but this failure—probably not in any way due to the process, but to the firing—has not made a good impression. The President thought it unnecessary to have made such a heavy sample. His opinion is that segmental retorts will be the retorts of the future.

Other Points as to Refractory Research.

The discussion did not touch very closely upon the subjects in the report; but Dr. Harker, just returned from America, was full of what is being done there. His advice to the gas industry is to support all co-ordinated work that bears on the investigation of fire-clay materials. He made one criticism of the report. In his opinion, while interested in the theory as to the reversal of the thermal conductivity of materials with certain kinds of pores at high temperatures, it was a pity that this part was presented before the results were available. In his judgment, too, instead of the Committee having only two new research assistants, they ought to have twenty. The importance of the subject needs no further emphasis than that given by Mr. W. Newton Booth, of the Woolwich Arsenal Gas-Works, when he stated that 30 p.ct. of the total expenditure on the works is concerned with fire-brick material. Thermal conductivity is subsidiary to getting a brick with good refractory and wearing qualities. In different parts of a retort-setting, there are two problems to be faced—one material must have a high thermal conductivity, and another a high thermal insulation. He is looking forward with interest to the information promised in the second part of the report, though he shares Dr. Harker's disappointment at the incomplete nature of the information so far given. That systematic research work on refractory materials is proceeding well is shown by the statement made by Sir William Jones regarding the new Ceramic Society, of which he is President. The plans that the Society have made have the full approval of the Committee of the Privy Council for Scientific and Industrial Research, and the steel industry looks upon the Society with favour. Dr. Mellor is taking the office of Technical Director; and he calculates on an expenditure of £6000 per annum, of which one-half will be contributed by the Privy Council Committee. There is every prospect that the other £3000 will be raised; and he hopes for the co-operation of the gas industry.

A New Gas-Furnace.

We must turn back for a moment to Mr. Newton Booth's remarks; for he mentioned an interesting development. He has been engaged on the design of a new type of gas-furnace, which is giving promising results, although only in the experimental stage. He mentions economies of 60 p.ct. in gas consumption, and an increase of over 300° C. in working temperature as having been attained, as compared with the common type of furnace.

Internal Corrosion of Mains and Services.

Some very good work is being done by the Gas-Meters Joint Committee, with Mr. J. G. Taplay and Mr. B. R. Parkinson at the helm. The excellent reports on meter troubles that they presented last year with highly practical conclusions are fresh in memory, and have helped the industry over a very awkward stile. By the report which Mr. Taplay next read, it is seen that the investigators have been dealing with the question of dust in both high and low pressure distribution systems, which some people have put down to vagrant oxide from the purifiers. These investigators can find no ground for this hypothesis; indeed, they discover the deposits contain much more ferric ferrocyanide (prussian blue) than is contained in purification oxide—21 p.ct. against 3·4 p.ct. in purification oxide. This shows that corrosion is responsible. Absence of lime in purification accounts for the passing forward of the bulk of the hydrocyanic acid; and the part removable by oxide is hindered by revivification *in situ*, especially when an excessive proportion of air is passed into the purifiers. The prejudicial effect of the hydrocyanic acid is increased by the presence of oxygen, while carbon dioxide plays a lesser part. Then the removal of the oily constituents of gas by the war time process of washing affects the matter, by the watery content condensing more readily in mains and services, and by the distribution system being deprived of the lubricating properties of the gas. Without moisture no corrosion is likely to take place; and it is at the "dew-point" that corrosion mostly occurs. There are more cases of condensation in high-pressure than in low-pressure distribution. The reporters approve the suggestion that the gas should be raised to a few pounds pressure above the distribution pressure; and while at this higher pressure, it should be cooled to its original temperature or lower—thus bringing down the water vapour content in excess of that which pertains to the pressure and temperature in the condenser. Subsequently the gas is expanded into the mains at a lower pressure, and passes through the distribution system well below its saturation point. This is known as the Helps system. At one works, the gas is compressed to 50 lbs. per square inch, is cooled, and subsequently expanded into the mains at 5 lbs. only. No corrosion or naphthalene deposit has been experienced. The condensed water brings down with it certain salts which play a direct part in corrosion. For low-pressure distribution, hydrocyanic acid should be removed, or protection be given to the internal surface of the distributing plant. A point of interest to those who engage in charge steaming is that, in the presence of steam and incandescent coke, hydrocyanic acid is converted into ammonia; while conversely ammonia in the absence of steam is converted into hydrocyanic acid by passing over red-hot coke. It is a point in favour of steaming. If, however, cyanogen washing is not indulged in, then lubrication of mains and services by atomized paraffin oil is suggested.

Spraying, Vaporization, and Other Points.

When Mr. Taplay had finished, Mr. Parkinson became the central figure. He told of how they had written to about forty gas engineers for information, and only twenty had responded. This does not show a universal respect for research work that is being carried out for the behoof of the industry. The recommendation made in the last report as to the spraying of meters appears to have been adopted all over the country; and, where used with discretion, it has been of value and an economy. An inquiry of Mr. H. R. Wimhurst, of Bury St. Edmunds, as to his experiences with spraying over a number of years brought from him a letter, which contains much valuable information, and is given *in extenso* in our full report of Mr. Parkinson's remarks. From the letter will be seen what is Mr. Wimhurst's practice in this matter. When he first started, he used a crude product, which had a bad effect on the leathers of meters. His experience has formed beliefs. He thinks the proper place to spray is at the governor outlet; and that it is better for the oil to be in mechanical suspension in the gas.

A large experience is in the possession of Mr. C. F. Botley, of Hastings. Using a crude distillate, he says they would expect unfortunate results on meter diaphragms; while refined petroleum is an advantage. In his own case there has been no trouble with naphthalene or corrosion. As to spraying meters and mains, his view is that it is better to do it at one operation at the outlet of the governor. He does not approve of spraying into a main alone with pressure; it is not so good as having a carburettor, and atomizing properly, so that one can see what is going on. From an experience he has had with large trunk mains, it is clear the atomizing of the oil must be done efficiently; otherwise there is a considerable amount of deposition of the oil. Nowadays there are in existence the best possible conditions for corrosion in mains; and where the oil process is not in use, trouble must be expected. The presence of excess oxygen in the gas is also bound to be detrimental. Mr. R. E. Gibson, of Liverpool, bore testimony to spraying; and, in connection with what he said, Mr. Botley interjected the remark that it is not a question as to the amount of oil put into the mains, but as to whether it is properly atomized when it is in the mains. The President cannot understand how it is possible to mechanically atomize the oil as beautifully as by proper vaporization. Mr. Thomas Glover, of Edmonton, speaking as a meter-maker, mentioned that, when naphthalene solvents are employed indiscriminately, whatever the effect may be upon the naphthalene, the results upon meters have been disastrous. If oil must be introduced into the gas, it should be of such a character that it would take right through the services and meters the compounds which are doing harm at the present time. He also suggested that it is not advisable to spray meters indiscriminately before fixing on the services. The experience of Dr. Davidson with fine dust carried in gas leads him to suggest that it is possible for fine dry oxide to be carried right through to the services. Now that the specific gravity of gas is higher, and the volume of gas is much greater to supply the same number of B.Th.U., these are two conditions that would contribute to the carrying forward of oxide. As to introducing an oil mist into the gas, the finest mist obtainable is certainly by vaporizing. The subject of putting in the oil by heat or compression was dealt with by Mr. Taplay in his reply. In one district of which he had experience, 3 gallons of oil per million cubic feet of gas are put in by atomizing, and nothing returns; and by vaporizing 15 gallons are put in, and 8 gallons are returned. As to Dr. Davidson's remarks, he asked whether, if the dust deposits come from the purifiers, it would not be certain that they would find them in the station meters, which they have not done. Moreover, the sulphur content in the deposits alluded to is only 1·3 and 1·05 p.ct.; and if they come from the purifiers, they would go up to 50 and 60 p.ct. None of the deposits contained peat, sawdust, or other things that would be expected.

Invitation to Contribute Written Communications.

The foregoing brought us to the end of Wednesday's sitting; and on Thursday morning, the President intimated that he had heard there were members who would have liked to have contributed to the discussions that had already taken place, and he invited them to send in communications in writing for publication in the "Transactions." He mentioned that Mr. Irminger, jun., of Copenhagen, and his own son would like to have said something on one of the subjects brought before the meeting the previous day, and possibly there were others.

Inter-Relation of the Gas and Dye Industries.

The agenda informed us that Dr. W. B. Davidson was to read a paper on this subject; but, though Dr. Davidson had prepared a communication, he did not read it. He spoke without the print; and the President's description of it as a "lecture" was more appropriate. To the great dye enterprise to which Dr. Davidson has transferred his affections (or part of them, for he continues to take a live interest in the gas industry) and talents, the members were greatly indebted for the beautiful exhibits with which the lecture was illustrated, and which made quite a formidable array before the lecturer.

We sat abashed while Dr. Davidson politely told us of our past shortcomings in this country in the chemical and dye industries, and the reasons why Germany before the war had got ahead, and had earned profits of a size which deepened our animosity towards the 2½ or 3 p.ct. to which the gas industry is condemned by a cold-hearted Parliament, the members of which should read Dr. Davidson's lecture, and so learn how essential are the products of the industry to the upkeep of other industries, and therefore to

the prosperity of the country. Dr. Davidson is a good commentator on, and judge of, all the matters he brought into the lecture. Trained in Germany, he speaks first-hand of its chemical ways, aspirations, work, and successes; and, having worked in the gas industry at home and now in the dye industry, comparisons, inter-relations, and such-like are readily made and focussed by him. We heard some complimentary things about the gas engineer. There was a time, it seems, when he of the British build was more pushful than the British chemist. But, however that may be, however tied by the bonds of tradition and rule-of-thumb the British gas engineer may have been, he has the satisfaction of knowing that he was the superior of the German gas man in working-up the consumption of town gas, so that the superiority of Great Britain over Germany in this particular was represented, per head of the population, by the ratio of 4 to 1. We were glad to hear one who can find an instance of superiority of this country over Germany; for it has of late years become a bit sickening to be always hearing the other tale. But in the chemical business, facts are too hard to allow us to decline to acknowledge the Teutonic superiority. In view of the stronger position of the British gas industry as suppliers of gas, this country was, relatively to Germany, wealthy in raw materials for chemical production; but our statesmen and business men did not assess the position at its value for national defence, advancement, and independence that they should have done, and did not utilize it. The Germans did. They took from us what we did not use; and they proceeded to develop rapidly their coke-oven industry to make their country independent of Great Britain in respect of materials necessary to industrial greatness—not merely in dyes and chemicals, but in industries in which these things are of their very life. For instance, it is not the value of the 2 millions sterling of dyes that before the war were imported into this country that matters so much as the possible effect of the supplies being cut off from the textile industries, which then represented a value of about 200 millions sterling per annum. Hence the need for the Government to maintain the carbonizing industries of this country in full and still increasing vigour.

The Need for Specialization.

The value of specialization in all branches of industry is one of the things that Germany has learnt. Though it is a good thing for industry, it is not for a man, as it makes him one-sided. The chemical industry is now something of very vast proportions; and its expanse is being daily added to by the new disclosures of research. The result is, as Dr. Davidson pointed out, a worker must specialize to have any chance of success. To roam all over the field is in most cases aimless and foolish. The want of recognition of this is where we failed; and where the Germans scored. We had as great intellectual capacity; they the willingness to study from the bottom any and every subject. The British chemist qualifies to pass a written examination; he does not read widely, and he is not interested in research. The German student has to carry on research for at least eighteen months; and most of the German University graduates in chemistry go straight to the chemical works, where they become specialists either in some line of research or in a works' process. It can be safely said that in 1913 there were twenty research chemists in Germany for every one in the United Kingdom. It is profitable to court science; and Dr. Davidson showed this by telling us of the development and profitable results that accrued therefrom to the Germans, from materials in which the gas industry is interested. Information was given as to the complete success, after toiling through years of partial failure, of the development of the platinum-contact process for making sulphuric acid. In the result, the cost of oleum (fuming sulphuric acid) in Germany was reduced to less than one-tenth of what it was formerly manufactured at by the old processes, and even for 90 to 95 p.ct. acid the cost compares favourably with that of similar acid made by the chamber plant and concentrators. Dr. Davidson here illustrated how in some chemical operations, the capital costs are enormous. For making 120 tons of oleum (by the contact process), platinum is required of the value at present prices of £90,000. This is about two-and-a-half times more than it would have involved before the war. Then we listened to an account of the development of artificial indigo; and while looking with detestation upon the bestial part Germany took in the war, one cannot, with Dr. Davidson, help admiring, in these chemical connections, the foresight, perseverance, enterprise, and resourcefulness which resulted in such magnificent successes. Then, again, there is Haber's synthetic process for the manufacture of ammonia on a large scale. This was a victory in the seemingly impracticable task of bringing about the combination of nitrogen and hydrogen in vessels maintained at a red heat, and working at the same time at pressures exceeding a ton per square inch. The process dovetails into Ostwald's simple and efficient process for making nitric acid from ammonia, and renders Germany more independent than ever of supplies of nitrate of soda from Chili. Dr. Davidson sees that the question of whether or not the manufacture of synthetic ammonia will materially affect the price of sulphate is an anxious one for the gas industry.

A Limit to the Industry's Chemical Ambitions.

Later on Dr. Davidson made out a strong case as to the indispensability to the nation of the industries which distil coal and recover various bye-products. This carried him to the question of the manufacture of intermediates and dyes, and here was warning against the popular delusion as to artificial dyes being produced by some sort of magic process from tar. There was a dig, too, at those company promoters who predict that, by one or other carbonization process, there are fortunes for those who will entrust their money to them. They say that they can get any amount of benzene, toluene, and anthracene from their low-temperature products by cracking or catalytic action. But what is it going to cost? In many chemical processes, the capital required is heavy; the plant very elaborate. There was also warning for the gas industry against carrying its chemical aspirations too far. Every encouragement should be given—even to the extent of a Government subsidy—to the production of the well-known primary aromatic hydrocarbons, including especially benzene and its homologues obtained by gas-washing. But the setting-up of plants to go a step further—that is, as far as the intermediates—is too risky for gas manufacturers to undertake, except in special cases. Then came the information that of the different organic compounds (some two hundred) in ordinary coal tar, only half-a-dozen or so are of commercial importance—benzene, toluene, xylene, phenol (carbolic acid), naphthalene, and anthracene. From returns, it is interesting to note how, as the war was approached, Germany's production of purified benzol and toluol increased. This looks highly suspicious.

Two Important Events in 1849.

In the historical part of the lecture, Dr. Davidson made the remark that there were two important events in 1849 which bore upon the subject of his lecture. The one was the coming of Hills' purification process and the other the establishing of the "JOURNAL," to which he paid a compliment for the value of its educational record. The French gas journal was founded three years later—in 1852; and the German one in 1858.

There was applause at the close of the lecture and the subsequent chemical demonstrations by Dr. Davidson; and there was further emphasis of the members' appreciation when the President formally moved a hearty vote of thanks to the lecturer, and to the Company who had contributed so much to the interest of the lecture by the exhibits of dyes and chemicals.

Message from the Italian Association.

A message was at this stage read from the President and members of the Associazione Italiana della Industrie Gas e Aqua. It contained sincere greetings and wishes that the coming peace may fortify the old friendships and ties of Italy and England. The friendly greeting had a suitable reply sent from the members.

Reinforced Concrete Purifiers.

As a structural material, reinforced concrete is destined to take a large part in gas-works construction; and the present-day cost of iron and steel structures will be an incentive to a larger consideration of reinforced concrete wherever applicable. Gas engineers have frequently had their attention drawn to this method of construction for purifier work; but few there have been who have dared to make the venture. But what has been done in this respect

by Mr. A. E. Broadberry, in the new imposing section of works at Tottenham, will perhaps do more than any precedent on a small scale has done to turn the balance in favour of the use of reinforced concrete for this part of the plant. These purifiers are on the large scale, being designed to deal with 5 million cubic feet per day; and a success has been achieved which gives the engineer complete satisfaction. But in the paper in which Mr. Broadberry described the reasons for his adoption, and gave the structural details, he omitted all mention of comparative costs, which is an aspect of the matter upon which his colleagues would have liked some detailed information. These were satisfied in his reply to the discussion.

Of course, the very nature of the work involves the risks of leakage and porosity; but there is abundant evidence in the paper that, if care is taken in the methods of carrying-out the structural work, and if a proper coating is applied to the inside of the purifiers, both leakage and porosity can be defeated. Mr. Broadberry told of the methods that he adopted. With all care in such work, slight initial defects must be expected, which are amenable to correction by a mixture of hot tar and pitch. Like other engineers, Mr. Broadberry has found that "Ironite" is an excellent internal dressing; but he would have liked, had time permitted, to have tried other coating substances, such as hot tar, tallow, paraffin wax, or other similar material. It would be highly interesting to have these tested for the purpose; but gas-works in these times are loath to try experiments of the kind when plant is badly wanted.

In studying the stresses when determining the details of the design, the most important of extraordinary stresses for such work as purifiers are those due to the pressure of the gas. In this case, it was assumed that 48 inches would be the maximum, which is equal to $1\frac{3}{4}$ inches pressure per sq. inch, and so constitutes a considerable additional load. The internal measurement of each purifier is 56 ft. 1 in. by 42 ft. 6 in.; and, at the pressure named, the floor load is increased by 266 tons in each purifier, which is equal to 1 ton per square yard. Though this portion of the load does not affect the foundations or supporting stanchions, it must enter into all calculations for floor structure, including the main and secondary beams. The same pressure acts as an upward stress on the decks and covers. The structural details will be found in the paper; but in this connection it would be instructive to learn whether any gas engineer has yet tried concrete covers, and with what result. Mr. Broadberry's experience has led him to the conclusion that reinforced concrete construction for large purifiers is very economical, and can be made more so if standardized in multiples of even feet dimensions, so as to allow of even shuttering. But the execution of the work should be in the hands of firms with experience.

Salient Points in the Discussion.

The discussion on the paper was not critical; it was congratulatory, with a few suggestions interspersed, and some inquiries. The war has been the means of driving Mr. Thomas Goulden (Gas Light and Coke Company) to the construction of reinforced concrete purifiers; and he is well pleased with the financial and structural results. Satisfaction with concrete purifiers which he has constructed was also expressed by Mr. Newton Booth. He has likewise experienced trouble at the joints where one day's work finished and next day's work commenced: and he cured it by drilling a number of small holes at the defective parts, and pumping in thin grout under pressure. There has been no more trouble. Four of his boxes are treated with "Ironite," and no leakage has been apparent. The fifth box he has treated to a solution of water-glass. Four coats were applied; and the effect is the same as "Ironite." Mr. R. B. Anderson supplied some details as to purifiers he has constructed with concrete bottoms and cast-iron sides. His objection to concrete sides is that these, being about 7 in. thick, would take off about a foot in the size of the purifiers. The President remarked that, though the concrete takes up more space, it does not corrode, whereas cast-iron plates do not remain at their original thickness. Mr. J. H. Brearley asked for comparative costs.

There were references to the two layers of oxide and to the splitting-up of the stream of gas so that there is upward purification in the bottom layer and downward through the top one. The President inquired whether there was any experience as to the behaviour in respect of moisture and distribution of the gas through the mass. The splitting of the gas flow in one purifier has not caused any trouble in Mr. Newton Booth's experience; but he has found it necessary to take the greatest care to ensure that the resistance of the flow of gas through the two layers was approximately equal. Now that the load has dropped, he has gone back to the old system. It was mentioned by Mr. H. Simmonds, of Bury, that he finds, in splitting the stream of gas, that the bottom layer takes up from 8 to 10 p.ct. more sulphur than the top one.

Among the points in Mr. Broadberry's reply, it was learned that he finds no difference between the activity of the top and bottom layers. In his opinion, Mr. Booth's experience was due to the rapidity with which he had to put his gas through; there was not sufficient time-contact. Regarding the joints, he has found no difficulty sufficient to justify the adoption of the remedial process used by Mr. Newton Booth. There has been no perceptible leakage at the joints; only a little discoloration. Mr. Broadberry also gave comparative costs. The details will be found in the full report; but, speaking generally, the reinforced concrete construction works out at about 100 p.ct. less than the iron construction, with steel lids in either case. This applies to both war and pre-war costs.

War Experiences of British Gas-Works.

The last paper was by Mr. H. Townsend, of Wakefield; and it places on record the uncomfortable experiences of British gas undertakings resulting from hasty bombardments by units of what was then the German Fleet, from aerial attacks, and from chemical works explosions which carried their work of destruction far beyond their own confines. There is historic value in this paper by Mr. Townsend; there is value in it, too, because it shows that, so far as gas-works are concerned, they came off comparatively lightly, though it might have been anticipated that, being vulnerable and important to the community and the nation, they would have been much more extensively the victims of the efforts made by the Germans by sea and land. But the fact remains that, by bombardments from sea, only two gas-works suffered any substantial damage—Hartlepool and Gorleston (Yarmouth). Gasholders, as a rule, are not set on a hill; but at the same time they form good targets if the light is good. Hartlepool bears very strong testimony to this. Wherever holders were struck, the gas simply fired, and burned itself out, as gas men knew that it would, though popular imagination had pictured the neighbourhood of gasholders as being anything but safe. Measuring gas-works experiences from bombardment with those produced by munitions factories explosions, the home-produced events appear to have caused damage to gas-works as great as, if not greater than, bombardments from sea. There was the explosion at a chemical works which put Ashton-under-Lyne and Dukinfield gas plants largely but temporarily out of action; there was the great Silvertown explosion, which found the 12 million c.ft. holder of the South Metropolitan Gas Company standing in its path, and raised objections from which the holder suffered; and there was the explosion at the works of the Low Moor Chemical Company, which had disastrous effects upon the North Bierley Gas-Works of the Bradford Corporation. The numerous air-raids, it appears, had relatively little effect on gas-producing plant. The chief trouble they caused was to distribution mains; and in London there was particularly great anxiety over those in subways. The destruction of houses, too, caused considerable loss of meters and fittings. But there was little explosion from escaping gas, due no doubt to the reduction of pressures during the raids. Of course, there was temporary inconvenience through reduced pressures while main repairs were being carried out; but, speaking generally, consumers suffered very little from the disturbance of their gas supplies. A great deal of credit for this is no doubt due to the activity of officers and staffs of the gas-works concerned, as well as contractors' men, in working with right good will to lighten the effects of this brutal enemy who bombarded from sea and air unfortified places, murdered men, women, and children, and destroyed homes with the greatest callousness. The day of reckoning has now come; and Germany whines. We on our part will not forget.

Mr. Townsend did not read his paper; but he had a large number of lantern slides of the ghastly damage done thrown on a screen, and he generally described the various occurrences. The members were vastly interested; and Mr. Townsend

felt well rewarded for the work he had put into the compilation by the vote passed by acclamation which succeeded.

Honorary Members.

The names of the Presidents of the French, American, and Italian Gas Associations were added to the list of honorary members.

Autumn Meeting and Place of Annual Meeting.

The President mentioned these matters. The Council have not yet decided whether or not there is to be an autumn meeting, and Sir Dugald Clerk has to be consulted as to his wishes regarding the annual meeting. Under the circumstances, decisions on these matters were left to the Council.

Votes of Thanks.

There were several votes of thanks. There was one to the President, and Mrs. Glover was united with him for her share in the hospitality and entertainment provided for the members and their ladies on Tuesday night. The Council, the Hon. Secretary (Mr. W. E. Price), and other officers were thanked, as were also the members of the Research Committees. Mr. Dunn had one all to himself, including hearty congratulations on his recovery to health. There was also cordial recognition of the generous hospitality to the Institution of the President and Council of the Institution of Civil Engineers.

So concluded the sittings of an annual meeting which all present declare to have been an unqualified success.

Status and Salaries.

In the afternoon there was a private and informal conference of those interested in these matters.

RECEPTION, DANCE, AND MUSIC.

We were back to the old times again in another sense on Tuesday evening; and it was the President and Mrs. Glover who brought us back by entertainment and other hospitality. It was at the Galleries of the Royal Institute of Painters in Water Colours in Piccadilly where they received their guests—a place which, before the even tenor of the world's ways was interrupted by war and brutality, was the scene of many a happy evening for the members of the Institution and their ladies. Things on Tuesday evening looked much as they did then; and we were all glad to be once again in the same old rooms with so many partners in the pleasures of similar occasions. The President and Mrs. Glover received all their guests individually; and, for an hour or more, they were shaking hands with over 400 guests. It was a big task to press into such a short time; but the President and Mrs. Glover found it a pleasant one, for there was no dropping of the warmth of their handshake or of the smiles with which greetings were made. At the end they looked as fresh as when they began. As soon as we had passed our hosts, Sir Dugald and Lady Clerk were found. Presently the President of the National Gas Council (Mr. D. Milne Watson) was seen; and the late President (Mr. H. E. Jones) looked in to meet old friends, and have a chat. We saw several members of the Council of the Society of British Gas Industries there, with their Chairman (Mr. Samuel Cutler, jun.) and his wife. The British Commercial Gas Association were represented by their energetic Chairman (Mr. F. W. Goodenough) and others. Orders were (by request) worn by those who had received them during the war; and several were seen—the one of greatest attraction being that of the new President of the Institution (Sir Dugald Clerk). Among other guests was Sir George Beilby, the Director of the Board of Fuel Research. The late President of the Institution of Electrical Engineers (Mr. C. H. Wordingham) was there; and he kept up the end of the electrical industry well among the gas men in dance and as a highly appreciative guest. There were Prof. Smithells and Prof. Cobb; and the Lord Mayor of Manchester (Alderman William Kay) wearing his massive chain of office. He had as a companion the Mayor of St. Helens (Dr. Bates) similarly decorated by the badge and chain of his dignified office. From St. Helens, too—also honouring the President and the Institution—were Alderman Crooks, the Chairman of the Corporation Gas Committee, Alderman Phythian, the Deputy-Chairman, and Alderman Peter Phythian, the Chairman of the Finance Committee. The evening was spent charmingly between dance and music, with occasional halts in the refreshment room. Nearly everybody appeared to be possessed of the desire to dance; and the room was always well filled with the whirling throng, flanked (right up to the walls) by onlookers who would have liked to have been with the gyrating ones had space or other opportunity permitted. However, as many as possible waltzed, did the one or two step, or went through the lively figures of the lancers, to the music provided by the Prince's Orchestra, under the direction of Signor Fortoni. There was no jazz music; nor any of the dances which have nominal distinction associated with the Zoological Gardens. Before the dancing commenced, and at intervals, the Westminster Singers in the large lounge delighted the company with songs, glees, quartettes, and other vocal music. The time passed quickly; and at 11.30, there were still some of the guests who wished for more, which tells its tale of thorough enjoyment and happy reunion.

New Members and Associates.

The following are the new members and associates elected:

MEMBERS.

Ablett, Ernest, Swansea.
Ames, Arthur Frederick, Padiham.
Balmforth, John Beaconsfield, Bingley.
Barrett, Ambrose, Frome.
Boardman, Frank, Cardiff.
Bond, Arthur J., Aberavon.
Bowen, M.Sc., Frederick, Leigh, Lancs.
Buckley, Edward A., Holmfirth.
Burton, William Thomas, Leatherhead.
Carmichael, Thomas, Portsea Island.
Collin, William, Coquimbo, Chili.
Collings, William Varwell, United District Gas Company.
Goats, Arthur John, Biggleswade.
Grant, Francis Robert George, St. Ives, Cornwall.
Hollingworth, David Vincent, Birchenwood.
Hoy, Hedley, Cannock.
Hungerford, John Thomas, Dunedin, N.Z.
Hunt, Herbert Atlee, Brixham.
Jennings, Arthur Lake, Spenborough.
Langford, Percy Norman, Coventry.
Macdonald, Robert Cowan, South Metropolitan Gas Company.
Macintyre, Donald M., Montrose.
Mitchell, George Porteous, Falkirk.
Moys, B.Sc., Herbert, Gas Light and Coke Company.
Newsome, Mark, Chorley.
Rees, Evan, Margam.
Rich, T. H., Millom.
Ritchie, Douglas, Aldershot.
Robinson, Frederick John, Chesham.
Royle, Harold Marmion, Gas Light and Coke Company.
Ruffhead, Alfred Ernest, Darlington.
Skinner, F. N., Martock.
Smith, Harold Charles, Birmingham.
Stewart, Edward George, Gas Light and Coke Company.
Twigg, George Frederick, Castleford.
West, Frederick Aldwyn, Newark.
Whitcher, Alexander Edward, Haywards Heath.
White, William Arthur, Glasgow.
Wilkinson, Robert Morton (Captain), Nottingham.
Willis, Frederick Charles, Tynemouth.

ASSOCIATE MEMBERS.

Kitto, Philip Sidney, Sutton.
Oxer, Sydney Joseph, Wandsworth, Wimbledon, and Epsom District Gas Company.
Poulson, Thomas Henry, Stafford.
Smith, Frederick S., Reigate.
Westworth, James Kenneth, Birmingham.

ASSOCIATE.

Oke, Alfred William, F.C.S., Southampton Gas Company.

GENERAL REPORT.

THE Annual General Meeting of the Institution was held last Tuesday, Wednesday, and Thursday, at the Institution of Civil Engineers, Great George Street, Westminster—Mr. SAMUEL GLOVER, M.Inst.C.E., of St. Helens (the President), occupied the chair.

The President's Welcome.

The PRESIDENT: Ladies and gentlemen, your presence here in such large numbers is a token to me that you are present to proceed with the programme you have arranged for these meetings. I greet you all with the heartiest of welcomes.

Confirmation of the Minutes.

The minutes of the last meeting of the Institution were taken as read, and confirmed.

Appointment of Scrutineers.

It was agreed that Mr. C. V. Bennett (Rochester) and Mr. R. Beynon (Torquay) should act as Scrutineers of the ballot-papers.

Visitors from Overseas.

The PRESIDENT: If Major Strange, a member of the American Gas Association, is present, I should like to welcome him to our meeting. [Major Strange stepped forward.] I am pleased to greet you, Major Strange, as an ally in gas, as you have been in the war. I congratulate you upon the two distinctions I see you are wearing. We have all the greatest of pleasure in welcoming you here as a representative of the Gas Association of the United States. [Applause.]

The PRESIDENT: Mr. T. O. Morland, of Sydney, we greet you heartily, and are pleased you have been able to join us here this morning. [Applause.]

The PRESIDENT similarly called upon Mr. J. N. Reeson, of Melbourne; but he was unfortunately, at the moment, not in the theatre.

The Presidential Address.

The PRESIDENT, amid hearty applause, then rose to deliver his address, which will be found on pp. 479-84 of last week's issue of the "JOURNAL."

Mr. A. E. BROADBERRY (Tottenham), proposing a vote of thanks to the President for his address, said: Ladies and gentlemen, it affords me very great pleasure to rise to give expression to what I feel is in all your minds—that we should accord a very hearty vote of thanks to Mr. Glover, our President, for the very interesting address which he has just delivered. Mr. Glover, as we expected of him, has put before us a great many subjects worthy of thought in the future, and he has spoken, as we expected he would, several very plain truths which will live with us for some time to come. At any time, it is a matter of anxiety for a President to prepare his address. But the year through which Mr. Glover has passed in the control of the Institution's work has been indeed a very trying one; and I feel that we must congratulate him upon the way in which he has conducted the affairs of the Institution, and for the excellent address he has just delivered to us.

Mr. JOHN YOUNG (Hull): It gives me the greatest pleasure to second the vote of thanks which has been so ably proposed by Mr. Broadberry. As he has said, Mr. Glover has more than exceeded the high expectations that we had formed when we were looking forward to his address. Mr. Glover has absolutely wrung his soul to give us the very best that was in him; and the best that he has given us could not, I venture to think, be beaten. It is no light task, as Mr. Broadberry said, to prepare a presidential address. In fact, if you will permit me to give you one little anecdote, perhaps you will know exactly what I mean. A Scot turned up late to work with a terribly black eye. "Who gave ye that?" he was asked. "Naebody gave it me," said the Scot, "I had to fight for it." I think that expresses it. Mr. Glover has laid down a high standard for those of the younger generation who are to come afterwards. There is a great future before the Institution of Gas Engineers and the gas industry; and I can only re-echo his wish most fervently that in the future "God give us men."

Mr. BROADBERRY: I think it is unnecessary to put this in a formal way. I will ask you to carry the vote of thanks with acclamation.

This having been done,

The PRESIDENT said: I thank you, Mr. Broadberry, for the way in which you have moved the thanks of the meeting to me for my address, and you, Mr. Young, for the manner in which you have seconded it, and you, Ladies and Gentlemen, for the way in which you have carried it. I thank you very much. I do feel indeed that the work of the Institution of Gas Engineers—the work of the industry—and our services to the nation, and therefore to the consumers that we meet with, is of the very highest importance. A higher importance can be attached to it than we have ever realized ourselves before. It needs all the power that can be brought to bear upon it. It needs the grit of the men of the North, the wisdom of the men from the East, the enterprise of the men from the West, and all those graces and qualities that the men of the South [loud laughter]—you have rather interfered with the trend of my thoughts, and I do not know whether I was going to say all the graces and qualities which they possess, or which are attributed to them. But we will leave that for the future to decide, because they are giving expression to all their very best qualities as all the men from the different parts of the United Kingdom are in the work of the Institution at the present time. I thank you.

Coal Stocks.

The PRESIDENT: It is suggested that at this point a message which I have received from the Coal Controller should be read; and, as you may want to send a message in return, I take this opportunity of reading the message received. It is as follows:

> Dear Mr. Glover,—With further reference to our conversation on Tuesday last, I find that the position with regard to stocks at gas-works is gradually improving, although the process is necessarily very slow. On May 9—I will give you the figures for May 16, one week later than this—the gas-works in Greater London held stocks averaging upwards of three weeks' consumption, and for Provincial works the average was two-and-a-half weeks. These figures are based upon the consumption in December last.
>
> As you will be aware, the position during last winter was very difficult indeed; and, despite the decreased consumption of coal due to rationing and the production of water gas, stocks were very seriously depleted. While, as I have already observed, stocks are now improving, it will I think be obvious to you that there are certain factors which either individually or collectively may tend to restrict the building-up of stocks, and these are as follows: First, the reduction in the working hours of miners as from July 16, 1919; second, the possible withdrawal of gas rationing; and, third, the withdrawal of the existing Calorific Standard Order.
>
> I very much appreciate all the assistance which this Department has received from the gas industry, and beg to assure you that everything possible shall be done to provide for and meet the needs of next winter.
>
> (Signed) EVAN JONES.

Is it your wish that any message, in answer to this very kindly act on the part of Sir Evan Jones in sending what comfort he could to this meeting, be formulated and sent to him?

Mr. SAMUEL TAGG (Preston): The question raised by the letter from the Controller is so important that I suggest the opportunity should be taken, in acknowledging the letter, to indicate, both to the Controller and to the Board of Trade, the considered opinion of the Institution upon some of the points therein raised. To enable this to be done, I beg to move the following resolution:

> "That the members of the Institution of Gas Engineers view with much alarm the suggested withdrawal of the

Calorific Standard Order, and request the Council to make the strongest possible representations to the Coal Controller and to the President of the Board of Trade as to the present position in regard to stocks of coal, and the certain effects of the withdrawal of the Order, before the coal situation is gradually improved."

This will enable the whole position to be reviewed by the Council, and enable them to take the fullest advantage of the opportunity offered to represent the situation both to the Coal Controller and to the Board of Trade.

Mr. J. P. LEATHER (Burnley): I wish to second the resolution which has been proposed. I am rather surprised at some of the figures which have just been given by the Coal Controller, because there must be a very considerable number of works which have nothing like the average stock which is there stated. We are now rapidly approaching the middle of the year—in a few weeks time it will be Midsummer—and not only the works with which I am connected, but many other places for which I can speak, say that their stocks are nothing like as high as the average figure which the Coal Controller gives in his letter. It is certainly advisable that we should continue to have a fairly free hand with regard to the admixture of water gas, in order to keep our supplies going in the winter which will soon be coming upon us—especially as I do not think that, as yet, there are any very large supplies of oil to enable us to make carburetted water gas of good quality. I wish to second the resolution proposed by Mr. Tagg.

The PRESIDENT: It is quite clear that these are average figures; and the fact that the average is higher than some of us have realized ourselves contains, to my mind, a considerable degree of comfort. If it is a fact that some of us have less than the average (and it would not be an average if it were not so), it does contain some comfort for us, because it will enable those who are controlling these things to send future deliveries to those who are least supplied. I have missed any message of thanks to the Controller for the message which he has sent us.

Mr. TAGG: It is in the letter.

The PRESIDENT: Oh! yes, Mr. Tagg mentions that there is a letter to be sent, and that has been very carefully composed to meet your needs. With regard to the resolution which has been proposed and seconded, I do not know (if you will excuse me) that this covers the ground in the best possible way. I advise you not to let it sink into your minds at all that the Calorific Power Order will ever be withdrawn—the Order for the restoration of 500 B.Th.U.

MEMBERS: But it is threatened.

The PRESIDENT: The fact that we have asked for it not to be withdrawn until the coal situation is improved takes up, I think, a weaker position than you ought to ask for.

Mr. TAGG: Will you allow me to say that this resolution conveys an instruction to the Council, and that the Council in their wisdom will prepare such a communication to the President of the Board of Trade and to the Coal Controller as the situation demands.

The PRESIDENT: I advise this meeting not to accept too weak a resolution, even giving an instruction to the Council, which admits anything, even tacitly, as is the case in this resolution.

Mr. R. G. SHADBOLT (Grantham): There are two points emphasized in the resolution. First, with regard to the future supply of coal; and, second, the suggestion of the possibility of the withdrawal of the 450 B.Th.U. Calorific Power Order.

The PRESIDENT: I am only advising you, as far as I can, to make the resolution admit nothing, and to make it as strong as you possibly can.

Mr. SHADBOLT: The strong point of the resolution is the anticipation—or any other word you like—that the industry would be placed in an impossible position during the coming winter. Ask for nothing; but point out the result.

The PRESIDENT: If, prospectively, certain steps are taken?

Mr. SHADBOLT: Yes.

Mr. JOHN KELLY (Bridlington): May I suggest that if the Order is withdrawn the inevitable result must be a greater consumption of coal at the gas-works? This should be embodied.

The PRESIDENT: That is another ground made clear in the letter. This point has been covered; but I thank you for reminding us of it.

Mr. T. D. LIVESEY (East Grinstead): With regard to your suggestion that the Order may not be withdrawn, is it not a fact that the limitation has already been withdrawn? I received only this morning a new Order insisting upon a 500 B.Th.U. calorific test. I wrote to the Board of Trade to call attention to the fact that while they had accepted the part of the report of the Fuel Research Board with reference to the pressure of gas, they had not adopted another part of the report which recommended 466 B.Th.U. for the calorific standard. The reply was that at the present time they could not possibly see their way to agree to a standard of less than 500 B.Th.U., as it would be necessary to have an Act of Parliament passed before the other recommendations of the Research Board could be given effect to. In these circumstances, does it not appear that the Board of Trade mean to insist on 500 B.Th.U. being resumed?

The PRESIDENT: I advise Mr. Livesey to handle this subject very carefully; and the fact that he has received such a communication strengthens me in advising you not to accept the possibility that 500 B.Th.U. is going to be imposed upon the industry.

Mr. TAGG: Will you allow me to amend the resolution by the deletion of the last six words? Then the resolution will read:

"That the members of the Institution of Gas Engineers view with much alarm the suggested withdrawal of the Calorific Standard Order, and request the Council to make the strongest possible representations to the Coal Controller and to the President of the Board of Trade as to the present position with regard to the stocks of coal and the certain effects of the withdrawal of the Order."

Mr. LEATHER: As seconder, I agree to the amendment.

The PRESIDENT: Do you accept the resolution in this form? It is certainly better than it was before.

The resolution, as amended, was put to the meeting, and carried unanimously.

Mr. SHADBOLT: Do we understand that the Council will actually draft the communication to the Board of Trade?

The PRESIDENT: Yes; and I want to see you about this afterwards, Mr. Shadbolt. The letter is being drafted. It will be all right.

Annual Report and Accounts.

[The report was noticed in the issue of the "JOURNAL" for May 20, pp. 427-9.]

The PRESIDENT: The next thing is the consideration of the annual report of the Council, of which you have all had copies. I move the adoption of the report, as presented.

Mr. THOMAS GOULDEN (London) seconded the motion, which was unanimously carried.

A Separate Meeting.

The PRESIDENT: I believe the report to be a true and honest representation of much serious and successful work done for the Institution; and take this vote as a vote of confidence. I thought it quite possible that the subject of education might have been brought up. You see we are considering in the Council the formation of a new organization of examinations and instruction; and we are studying the subject right up from the gas-fitter to the gas distributor and engineer. There is another subject I thought might have been asked about the report—a subject that needs, I think, a separate meeting from any we have fixed on our programme. We propose to offer you a meeting on Thursday afternoon for a thorough consideration of this subject. [A VOICE: What is the subject?] The subject is the status and salaries of gas managers. I thought it was quite understood to what matter I referred. The meeting is called for those interested in the subject, and for nobody else.

The Case of the Ex-Service Man.

Captain STALEY: May I be allowed to say a word or two with regard to the presentation of the report, so far as it deals with demobilization?

The PRESIDENT: I should be very sorry to prevent you from doing so.

Captain STALEY: I wanted to say a few words on the subject of demobilization; and I do so with very great diffidence, because I fully appreciate the fact that the majority of the members of the Institution are thoroughly alive to what is owed to active service men especially, on their return to business life. But there is one point I want to make apparent, and it is that everything which is possible is not being done. There are still very great discrepancies, and there are injustices, and things that are too despicable almost to speak of, being done to ex-service men with regard to re-instatement. There are undertakings which are not even offering re-instatement; there are undertakings that are offering re-instatement which is not re-instatement, but an insult; and there are a great number of committees, boards of directors, councils, and the rest of them, who absolutely refuse to consider an application from an ex-service man. I could easily quote cases; and Mr. Shadbolt knows of instances. I rise with great diffidence, because it will be at once thrown at me that I have an axe to grind. But that is not my purpose. I want justice for the service man; and as the industry has sent only a few men comparatively on active service—though they have all been engaged on war work of vital importance—I think you should all recognize the claims of the few service men there are, and that they should not only be done justice to, but should have preference. I do not know whether you think it is worth while going into the status of gas engineers and the bringing of our younger manhood into the industry, while the industry is allowed to treat some of the best manhood in the way it is doing at present. I do not wish to move any vote of censure, or to "reduce Mr. Shadbolt's salary;" but it is because the industry should not be allowed to do these things in a corner, and no one know of them, that I have resolved to make this protest to-day. [Applause.]

Mr. R. G. SHADBOLT (Grantham): After the remarks of Captain Staley, it remains with me to say something as Chairman of the Demobilization Committee of the Institution. It will be a difficult matter to reduce my salary, I am afraid. But that is by the way. First let me say that I think that Captain Staley has taken the right course. It requires a great amount of courage to come forward before this Institution and state his own personal case, however lightly he may have touched upon it, because it is one of the cases referred to in our report, where we consider that considerably less than justice has been done. The Demobilization Committee are most sympathetically inclined to cases like that of Captain Staley; and within our powers we have done all it is possible for us to do. You must remember, and the members must remember, that we have no compulsory authority of any kind whatever. We make all kinds of efforts to bring before authorities who have appointments to make the necessity and advisability of giving ex-service men the preference to the utmost extent; and we are satisfied that in most cases this is done. Unfortunately, in a number of instances it is not so, and we do not attempt to burke it. What can we possibly do? Are we to pillory them? [Cries of "Yes."] Have we your authority to pillory them? [Renewed cries of "Yes."] Hitherto we have interpreted our duty as mediating between the parties, and we have offered our services to both sides in order to bring about reconciliation. If we pillory them, we must have the requisite authority from the Institution, because we must stand the racket of whatever follows. We have so far interpreted our duties as lying in the direction of conciliation rather than provocation. But you can easily imagine a case, such as has been stated by Captain Staley, where the position, if the man returned to it, would be untenable, because of the state of tension which would exist. The question is: What is the remedy? What can we do? We have no powers of compulsion at all. The only weapon left is that of pillorying an undertaking or a chief official. That would be a very serious step to take, and would require absolute proof on every point before we could do so. Our sympathy is entirely with Captain Staley and any others who have been treated in a similar manner; but we are powerless to do anything more than we have done. This is the difficulty; and if the Institution would take to its heart such a case as that of Captain Staley, and where vacancies are existing at the present time, and men of ability such as Captain Staley can prove are forthcoming, who have served their country, it is your duty, as well as the duty of the Demobilization Committee, to see that such men are appointed when such vacancies occur, by doing your utmost to secure the appointment, and not leave it to a small powerless Committee to do the impossible. If members of the Institution would work in this spirit, I do not think that cases like Captain Staley's would exist very long.

The PRESIDENT: I hope, Mr. Shadbolt, that the industry will feel the burden of the bad behaviour of these people, whom we have to leave to the judgment of God, I am afraid. I trust that Captain Staley will soon be able to say to these people: "Your money and your position perish with you." I hope, Captain Staley, you will live to smile on the experience you have left behind you at the place you are thinking of at the present time.

Captain STALEY: Thank you, Sir.

Mr. SHADBOLT: I think I ought to put it very plainly, so that no one may misunderstand the position. The position is purely and simply this: Captain Staley has been offered re-instatement at the pre-war rate of remuneration.

The PRESIDENT: It is quite understood, Mr. Shadbolt.

Report of the Gas Investigation Committee.

[For report, see p. 607.]

The PRESIDENT: I have very great pleasure in calling on Prof. Cobb to introduce the report of the Gas Investigation Committee.

Prof. COBB: I believe Prof. Smithells has a few remarks to make first.

Prof. ARTHUR SMITHELLS: I think the first choice was the proper one. Everyone knows that Prof. Cobb has had chief charge of the supervision of the research which has been carried out under the auspices of our Committee; and as time is precious, I ought not to interpose for more than a moment.

The PRESIDENT: We leave it to you. I hope you will not hurry unwisely.

Prof. SMITHELLS: I need only say that since the last meeting of the Institution in the autumn, the circumstances under which we are carrying out our work have somewhat improved; and during the last two or three months we have shared in the general relief afforded by demobilization. We have increased our staff, and obtained other facilities; and we hope that during the current year the effect of this relief will be very much more evident. I ought also to say that our work unfortunately sustained serious interruption owing to the severe illness of Mr. Wood, our Research Chemist, now happily restored to health. It will be seen from the report that we have diverted our work from the line which it was following, in order to carry out an investigation into the efficiency in use of the gas being made at Uddingston; and I hope that this departure will be approved, and the results will be found of value. At the same time, I must say again, as I said last year, that what we are bringing before you is rather a disclosure of the progress of the inquiry, than anything in the nature of a formal or finished report. We must therefore not be blamed if at the present juncture the conclusions put before you lack any measure of definiteness or finality. Speaking as the Chairman of the Committee, I may say that the Committee has been extremely assiduous in carrying out its duties; and I should like to say how much benefit we have obtained from the President's participation on more than one occasion. I think we all continue to be highly satisfied with the staff we now have at our disposal for the conduct of the work.

Prof. COBB: The report has been introduced briefly and modestly by Prof. Smithells, who is once more in the position to give that close attention to his duties as Chairman of our Research Sub-Committee which we have become accustomed to expect, and which, I may be permitted to say, we prize so highly. I should like to give a little general explanation before Mr. James W. Wood, the Research Chemist, presents a more detailed account of the substance of the

work with which he has been concerned. Every time we meet here, the importance to the industry and to the nation at large of economy in the use of fuel becomes more obvious; and although the gas industry has a strong position in this respect, there are great possibilities before it, largely owing to the promise of liberty for technical development which the new standards proposed for gas seem likely to afford. We have the opportunity at Uddingston, for instance, of obtaining data concerning one typical development—steaming in vertical retorts—which promises a higher percentage of the fuel value of the coal in the gas along with some other advantages; and we now have a Research Chemist, Dr. Parker, and two assistants, giving the whole of their time to this branch of our work. There may be some little disappointment that we cannot report results at this meeting in this particular connection; but I am quite certain that you will agree that, if the testing is to be done by the Institution and the University of Leeds through the Research Committee, it must be done properly. If any of the work that we have carried out already has been of use to the industry, or if, as we hope, it has been of service to Sir George Beilby and the Fuel Research Board, in the consideration of the problem before them, it is only, I believe, because the report already issued contains internal evidence of a determination to exercise every care and take every precaution compatible with obtaining trustworthy results in a reasonable time. You will readily understand that we were not able to commence our work at Uddingston until after the conclusion of the armistice. Dr. Parker actually started there at the beginning of February; and there has been a very large amount of preliminary work to be carried through before the testing proper could start at all. Apparatus had to be assembled, measuring instruments of different kinds had to be calibrated or checked, tanks had to be measured-up, the nozzles used for the supply of steam to the retorts had to be calibrated for different pressures in order that the quantity of steam used should be known with some degree of accuracy; and all these things take time. The actual testing is now on the way; but where so much depends upon the comparative results obtained under different conditions, it would have been premature at this stage to commence publication. The work at Uddingston, however, is linked-up to the investigations we have already been carrying out on the comparative efficiency in use of different grades of gas, because the steaming process, if carried far, produces necessarily a gas of calorific value below the normal of to-day; and no question calls more insistently at the present time for an answer than this. Assuming that such a process as steaming in the retort or the gasification of coke in a separate generator renders it more economical to make and distribute a gas of 400 B.Th.U. per c.ft. than one of 500 or 600 B.Th.U., can the gas so made be used with efficiency? We turned aside to some little extent from our systematic survey of a number of different grades of gas in existing appliances, and the subsequent study of efficiencies in modified or special appliances, in order to answer the question; and the results of experiments made to this end occupy the principal portion of the report before you. In this part of the work we made any alteration which seemed advisable to the appliances that we tested, though as a matter of fact such alterations were of quite a minor character. In addition, we have carried on the more systematic survey to which I have referred—particularly on mixtures of coal gas with gradually increasing admixtures of blue water gas; and the result obtained in this connection also appears in the report. It is interesting to study thoroughly the two reports now issued, with a view to summarizing their indications. I should feel inclined to say that their main suggestion is that, for a very wide range of composition and calorific value, different gases can be made with very much the same order of efficiency if the appliance used for burning the gas is suitably designed, constructed, and adjusted, and that the results confirm the essential rightness of the proposal of the Fuel Research Board to base the charge for gas on the heat units delivered in it. The necessity for all-round care with the appliance, if the efficiency is to be a high one, becomes more urgent, roughly speaking, as the temperature of use increases, and is more critical when the shape and size of the flame become of dominant importance, as in lighting. It is not unfair to read into our first report, where results were obtained without any alteration to existing appliances, the meaning that the design and construction of these appliances has gradually evolved in such a way that they have come to be made more specially suitable for gas between 500 and 550 B.Th.U. in calorific value. Very good results can be obtained with richer gases; but I never until recently appreciated how peculiarly justified was the insistence on the utmost care in the design and construction of appliances when the use of gas was in question. Gas below the normal in calorific value, as made at Uddingston, is more elastic in its requirements. But the report, I believe, is suggestive there, and shows how much the success of the industry in the future, when gas of different grades comes to be used, will depend upon the closest collaboration between the gas engineer and the maker of appliances, and whoever may be concerned with the adjustment of an appliance, before it is left to the sole control of the consumer. Finally, I should like to express my thanks, and the thanks of the Committee, to the Birmingham Corporation Gas Department and the Uddingston Gas Company for the facilities they have afforded, and to Dr. E. W. Smith and Mr. Lawrence Hislop for their valued collaboration. Mr. Wood, our Research Chemist, has been primarily responsible for the carrying out of all the experimental work described in the report. At all times, but more particularly when work has to be carried on away from Leeds, it is necessary that the Research Chemist should be one in whose work the Committee can place complete confidence; and we are fortunate in having been able to call upon Mr. Wood's services. He will now be able to speak for himself.

The Question of Inerts.

With your permission, however, I should like to make an additional, and strictly confidential, statement. It concerns the question of inerts, which is so important at the present time that I venture to report the results of some experiments, although they have not been submitted to the Committee and received its official sanction and endorsement, for the simple reason that they have been obtained since the last meeting of the Committee, and have only this morning been placed in my hands. I had arranged with Mr. Wood to to make some practical tests of the influence of a typical inert constituent by taking a straight coal gas, low in inerts, and adding nitrogen to it in stages—making a series of tests with the upright incandescent burner on the mixture at each stage of the dilution. The results and their implications will be treated fully later on; but the following statement can be made with confidence, I think, at this stage. If a straight coal gas of (say) 625 B.Th.U. gross be diluted with an inert constituent, nitrogen, until the calorific value is reduced by stages to 450 B.Th.U. gross, the mixtures so obtained show no differences of practical importance as regards either attainable candle-power or thermal efficiency, provided that the heat units are delivered at the same rate. The only modification made in the burner during these tests was the opening-out of the nipple orifice.

Mr. JAMES W. WOOD, M.Sc., A.I.C., then indicated the principal features of the report.

The PRESIDENT: Thank you very much, Mr. Wood. The subject is now open for discussion.

Mr. JACQUES ABADY: May I, as a visitor, be allowed to make a few remarks? This is the second report of the Committee; and I want to draw attention, in a few words, to the essential difference in the circumstances in which this report is made and the previous report. The previous report was made before any adumbration of Government policy was forthcoming. Since the report was made, however, the Fuel Research Board have reported to the Board of Trade, who have made the report public; and there they have definitely stated their recommendation as to their future policy in respect of legislation on gas quality. This policy is based upon two essential assumptions—one, that there is calorific parity, or that there is financial parity, between gases of different calorific value; and the other, that it is necessary to make a statutory limitation in the amount of inerts. The work of the Investigation Committee has been directed to both these points; and I think that I remarked, either in the Press or at a previous meeting, that I thought it would be found—speaking from many years' personal experience of making tests, and having gone over most of the ground—that the value of the Investigation Committee's work would really be to confirm the obvious—that gases of different calorific power have the same value per B.Th.U., and that one had never been able to discover within the limits of any reasonable percentage of inerts, when given the use of an appropriate vehicle for

consumption, that there was any difference in the thermal efficiency the consumer obtained. I think this report amply confirms this view. It is rather unfortunate that the latter part of the report has been included, particularly the table at the end, because this table, on the face of it, upsets the assumption that has been made by the Fuel Research Board, and upsets the results one has obtained hitherto —that there is parity as between one heating power value and another—because the table seems to me to show that it requires more B.Th.U. to produce a candle power when the calorific power drops than when the calorific power is high. That is, of course, wrong. I do not say the tests are wrong; but the reason why this result is shown is because the Committee did not do what Prof. Cobb in his final summary said was necessary—they did not use the appropriate vehicle for the burning of the gas. I am not carping in any way; but I do suggest to the industry that, as the Fuel Research Board of the Board of Trade have at last been screwed up to agree that 400 B.Th.U. is worth four-fifths of 500 B.Th.U., why should they, by any kind of half-reading of the results, depart from this position with respect to the remainder of the report? I think that this admirably confirms what one expected, and it particularly confirms the fear that the suggested limitation to 12 p.ct. of inerts is a retrograde movement. I suggest that, before the report is sent forward, it might be considered whether the latter part of it, including the table I have specially referred to, should not be deleted.

The PRESIDENT: Prof. Cobb, I should like you to deal with this point now, because of the consideration you put before me this morning of introducing these later notes.

Prof. COBB: I believe that the real answer to what Mr. Abady has brought forward is to be found in the substance of the report itself. We set out with a perfectly definite scheme; and on the scheme we have worked. The plan was that, in the first instance, we should determine how far different grades of gases behaved differently in existing appliances; and a number of tests were made on different grades of gas on the same burner. It is clearly indicated that the differences so obtained are not necessarily in any way differences inherent in the grades of gas. This has been made, I think, perfectly clear; and the table gives the results of a series of tests made on the same burner, gradually altering the composition of the gas. I believe the inner meaning is simply that the burner, being a burner of to-day, is one which I have said has been gradually evolved in order to deal with gas of a certain kind, and was less suitable for dealing with other gases which departed from the particular grade, either in calorific value or composition. It would be a great mistake if we were in any way diverted from this plan of making the complete survey. We come, now, to the second part of our work, which is the influence of modified appliances—the influence of the efficiency of different grades of gas when the appliances are chosen or modified in order to meet the particular requirements of each different grade. You will all know that a circular letter has been sent round, in order that as much information as possible can be brought to the knowledge of the Committee as to what has already been done in the design of appliances for dealing with gases of grades which are different from the normal of to-day. We are hoping that the letter will bear fruit—that it will be seriously considered not only by gas engineers, but by those who are concerned with the design and construction of the appliances. The second part of our survey has not yet really started, excepting in one or two special cases. We diverted the work in order to be able to make a definite assertion as to gas of the kind manufactured at Uddingston, when we did allow ourselves to make the necessary modifications in appliances. This was done because time pressed, and it was very necessary that we should secure quickly an answer to this particular question. You must bear in mind that, so far as we can make out, burners are not yet in use for dealing, with the highest degree of efficiency, with all the grades of gas that are possible, or that are even likely; and there are opportunities before all branches of the industry in this direction. We are hoping to have the chance of demonstrating some of the new appliances that are brought forward for their special excellencies; and we are asking you to commit the testing of these appliances to our charge, if you trust us to that extent. On the question of eliminating from the report what is really and logically one step in coming to our conclusion, I have no hesitation in saying I think the report would be impaired by the omission of the table, for reasons I have given.

One B.Th.U. not as Good as Another.

Dr. W. B. DAVIDSON (Huddersfield): I think it is an unworthy suggestion of Mr. Abady's to eliminate the last table of the report. In my opinion, this table represents the truth—the facts. And I also say that is just what theory would expect, or approximately so. I contend that one B.Th.U. is not as good as another—that it depends upon the company it keeps. I pointed out at the last meeting that the flame temperature ought to be considered, and particularly the percentage of CO_2. Would any practical man attempt to melt certain metals with producer gas, or a gas containing a high proportion of CO_2? He would not. He could not get the temperature. In the case of boiling water it is different, because the temperature head is sufficiently large with the poorest gas, and therefore one B.Th.U. is as good as another. But where it is a matter of flame temperature, then the specific heats of gases at high temperatures play a very important part; and it is a well-known fact that CO_2 at a high temperature, or even at an ordinary temperature, has a much higher specific heat than any other gas contained in combustible gases. When these are the facts, you cannot but expect that a combustible gas that is seriously contaminated with CO_2 would give a lower illuminating power, because the flame temperature would be lower. It would give a lower efficiency in melting most metals, for the same reason. It would be a very sad thing indeed if the table were cut out, as it represents the truth approximately. I think that the previous report did an injustice to the gas industry in giving low values—in not giving the best results —and I am glad to see in the present report these results are very much improved. We still have it that Uddingston gas of low calorific value gives an efficiency in incandescent lighting of approximately 25 p.ct. less than coal gas. Whether this matters a lot I leave it for you to judge; but I think the report would not be complete if it did not investigate the efficiencies in metal melting, where flame temperature would play an important part.

Mr. L. GASTER: I have listened with very great interest to the report of the Committee, because recently, as many of you know, I have taken a very impartial attitude with regard to illuminants. A lot has been said that gas is going over from lighting, and that the half-watt lamp has killed gas for lighting purposes. But I stand up here and thank the Committee for having carried out the investigations they have on the use of gas for lighting purposes with a view to obtaining the best type of apparatus to give the most efficient results. It is most important for the public to realize that, if any alteration is made in the character of gas, gas can be employed with suitably designed and properly used appliances. It is no use employing gas in the wrong apparatus, and then saying that the gas industry should not interest itself any longer in gas for lighting purposes. Most of the present apparatus is unsuitable, and many of the burners have regulators which burn the fingers when they are touched. This is not a suitable arrangement. But if suitable appliances are designed, and the consumers are made to understand the advisability of using suitable appliances, there is no doubt that gas and electricity can go on in competition and in friendly rivalry.

Mr. T. DUXBURY (Oldham): I am very pleased to know, from what the previous speakers have said—Prof. Cobb, Mr. Wood, and Mr. Abady—that we are pretty well in unison so far as getting down to 400 B.Th.U. gas is concerned. Most of you are aware that we in Oldham have been experimenting for twelve or eighteen months with various grades of gas; and I can assure you that, with our present quality of from 410 to 420 B.Th.U., we are giving every satisfaction, both for lighting and heating as well as for cooking. But that is not the point I wish to say a word or two upon. It was more the question of inerts in the gas. We have been making some tests during the past fortnight on boiling ring-burners with gas containing about 38 p.ct. of inerts, compared with gas containing 14 p.ct. of inerts. The inerts in the 38 p.ct. were chiefly air, not CO_2; and we found that, with an improved cooker hot-plate burner, the amount of gas used with the 14 p.ct. of inerts to boil one quart of water was 1·522 c.ft., while with the gas containing 38 p.ct. of inerts, the quantity of gas used was 1·456 c.ft.—a

decrease of 4 p.ct. The net calorific value of the gas with 14 p.ct. of inerts was 384 B.Th.U., while with the 38 p.ct. of inerts, it was only 368 B.Th.U.—another decrease of 4 p.ct.

The President: I should like to ask you if it was the same burner under exactly the same conditions, without any adaptation for the varying qualities of gas?

Good Results with 38 P.Ct. of Inerts.

Mr. Duxbury: It was the same burner regulated to get the best flame in both cases—the same burner, the same kettle, and the same distance from the burner, but regulated in both cases to get what we consider to be the best results. We, in Oldham, are somewhat peculiarly situated. We have three works, and our mains are connected in the town to be able to send the gas from any of the works to almost any part of the town, and especially from two of the works. In one of these we have simple vertical retorts and nothing else; in the other works we have horizontal retorts with compressed air stoking machinery and nothing else. These two works are so connected that, when the vertical works are shut-off, the whole of the gas from the horizontal works goes into the same district to the same consumers; and this 38 p.ct. of inerts gas was made on the horizontal retorts purposely, by simply drawing-in air. On the vertical retorts there was 14 p.ct. of inerts by steaming in the usual way; and we found that the gas containing two-and-a-half times the inerts, although 16 B.Th.U. lower in calorific value, uses 0·066 c.ft. less of gas, or 48 B.Th.U. less, and is 6·62 p.ct. greater in efficiency. This is a point I would like members to investigate for themselves, and also the members of the Research Committee, because I am candidly of opinion that inerts in gas up to a certain percentage—which I am not prepared to state as proved—is not material to the gas supplied, and is not detrimental to the gas supplied, so far as the results on a boiling burner are concerned. With regard to street lighting by incandescent burners, when we have the vertical works shut-off, and we are supplying gas with 38 p.ct. of inerts, we get quite as good a light in the street lamps; and I may say that we have been told repeatedly, and often by electrical people in Oldham, that since we came down to 410 to 420 B.Th.U. gas there has never been better street lighting in Oldham. This is neutral opinion, and not my own. It is my own opinion, certainly; but it is neutral opinion also, and has been given often by members of the Electricity Committee. We are thoroughly convinced that the lower grade gas (400 B.Th.U.) can be made to do any work, so far as heating, cooking, gas-engine, and even lighting is concerned—I do not say metal melting, because we have had no experience with it for this purpose—that any 600 B.Th.U. gas can be made to do, especially by the adaptation of appliances. It was chiefly on this question of inerts that I wished to speak to-day. A gas with 38 p.ct. of inerts will give as good results as—in our case it has given better than—a gas with 14 p.ct. of inerts. Then why limit the inerts to 12 p.ct.? I should certainly like the Investigation Committee to try in some way either to prove these figures or otherwise. These are actual figures that we took out of a large number of tests last week, so as to be in a position to say what we have found. There is one peculiar feature with regard to gas with 38 p.ct. of inerts in it—I have noticed it for months—and that is that, with the same calorific value, it gives a much better light in a flat-flame burner than gas with only 14 p.ct. of inerts. I should like you to test this for yourselves. We have proved it repeatedly, time after time—not once, but scores of times, and for months—that a flat-flame burner using 420 B.Th.U. gas gives a better light with 38 p.ct. of inerts than with 14 p.ct. There is also one other point which affects most of us, and that is the naphthalene question. We found that since we had this large percentage of inerts—this 38 p.ct., but I am not going to explain why these things really are [laughter]—we have not had a single complaint of naphthalene in the street-lamps. It is a peculiar statement to make; but these are facts that we have discovered. These are the principal points that I wanted to mention; and I should like other gentlemen to make tests for themselves. We are all in a position to find out whether gas with a large percentage of inerts will do the work as satisfactorily as a gas containing a small percentage of inerts.

Mr. T. S. Lacey (late of Beckton): Are the inerts introduced after purification?

Mr. Duxbury: These experiments have been made on a straight gas.

Mr. Lacey: Where are the inerts introduced in the case of the 38 p.ct.?

Mr. Duxbury: Before purification and before condensation.

Mr. Smith: May I venture to ask if the inerts are of the same composition in the case of the 38 p.ct. as in the case of the 14 p.ct.?

The President: A very interesting question.

Mr. Duxbury: The composition of the gases in the two cases was as follows: Carbon dioxide, 5·1 p.ct. for the 14 p.ct. inerts gas, and 4 p.ct. for the 38 p.ct. inerts gas; unsaturated hydrocarbons, 1·7 p.ct., against 3·3 p.ct.; carbon monoxide, 17·10 p.ct., against 5 p.ct.; methane, 17·40 p.ct., against 25·3 p.ct.; hydrogen, 49·8 p.ct., against 28·3 p.ct.; nitrogen, 7·7 p.ct., against 31·4 p.ct.

The President: How do you get the different percentage of hydrogen?

Mr. Duxbury: I take it that is on account of the greater percentage of nitrogen.

The President: Can you give us the oxygen?

Mr. Duxbury: I am sorry I left out the oxygen. In the 14 p.ct. inerts gas it was 1·2 p.ct., and in the other case it was 2·7 p.ct.

American Experiments.

Major Strange (Honolulu): I hope you will excuse my making a few remarks in connection with the Investigation Committee's report, as it is several years since I was in the gas industry—that is, the natural gas industry; I do not mean poison gas. The Chemist of the Pacific Coast Gas and Electric Company, Mr. F. C. Jones, several years ago made some interesting experiments in relation to the values of gases of different calorific values; and he discovered this rather remarkable coincidence—that in a cubic foot of perfectly combustible mixture, there are exactly 100 B.Th.U., irrespective of whether the gas that is used contained originally 1000 B.Th.U. or 320 B.Th.U. That is, take a mixture of acetylene gas, roughly 1000 B.Th.U., and mix it with a proper proportion of air, in a cubic foot of the mixture you will find exactly 100 B.Th.U. This holds good, he found, from 1000 B.Th.U. down to 320 B.Th.U. Below 320 B.Th.U. it no longer held good. But between these limits Mr. Jones designed a rough test for ascertaining the calorific value of gas by means of a quick analysis by the explosion test over mercury, of the amount of surplus oxygen required to explode a given amount of gas. This is exceedingly accurate, and is a method used generally throughout the United States for roughly determining, within 2 or 3 p.ct., the calorific power of gas. This holds good so far as gas used in household appliances is concerned and for lighting. But when it comes to metal melting, then, for some extraordinary reason, it no longer holds good. While you get 100 B.Th.U. in your mixture, you do not get the same value in metal melting for different kinds of gases. Mr. Jones did not have the opportunity of pursuing this further; and the probability is, as Dr. Davidson pointed out, that it might have been due to the different composition of the gas and the different amount of CO_2 or the amount of nitrogen. I was rather struck by the remark of the President in his address that it was necessary, in connection with appliances, for the manufacturer to collaborate more with the gas engineer. In the United States this point was taken up many years ago. It has been recognized there that it is more or less useless for a gas engineer to give all his thoughts and attention to making a very fine quality of gas as economically as possible, and then sit down and put it into the hands of a comparative stranger to sell it for him, and get the best result for the public. In the United States there is a great deal of co-operation between the appliance manufacturer and the gas engineer. Also they believe in advertising a great deal—probably, I think, more than you do here. For instance, one is very much struck by the statistics that your President has given us as to the excellent work of the gas industry during the war. But how many people know of it? The general public think that the bulk of the people who are interested and have worked in the manufacturing field are more or less profiteers; and it comes rather as a shock that

the gas industry, which has done so much for the country, can prove to be the one set of people who were not profiteering. The public ought to know this. In the States, they would have known it long ago. There is another fact in regard to advertising. They make it their business to see that the consumer appreciates thoroughly the troubles and the difficulties that, as gas men, they are up-against; and they make them believe that they always have the consumers' interests at heart. This is done by means of advertising. Of course, you also have the consumers' interests at heart in this country. But the public do not know it; otherwise you would not see such articles in the Press as you do from time to time, as, for instance, that "at last the Board of Trade have discovered that gas companies have been cheating the public for many years, and that they are now going to charge them not so much per 1000 c.ft., but according to the number of B.Th.U. which run through their meters." I saw that in the "Daily Express" the other day. Many comments of this kind occur; and if the public (I am a thorough believer in the fairness of human nature) understand exactly what you are trying to do for them, and believe in you, then I am sure you will always have their hearty and cordial support.

The Reports Criticized.

Mr. W. W. TOWNSEND (Colchester): The point I want to make is the great difference between the preliminary report issued last October and the present report, and the fact that you have not, so far as I can see, revised the preliminary report. I venture to suggest that it would be a very good thing if you did so. Personally, I feel rather sorry that the order was not inverted, and that you did not begin by investigating on the lines of the last report. Summed up in a word, the difference between the reports is this: In the first, you devoted all your attention to altering the pressure in order to get the different volumes of gas through; while in the second, you did what I suppose most practical men would have done at the very start, and adjusted your burner by simply rimering out the nipple. This small variation has made all the difference in the world to your results. I understood Prof. Smithells to say, in introducing the report this morning, that the conclusions stated therein were not as definite perhaps as they might have been, the reason being, of course, that the results are not conclusive and the report is not definite. I should like, however, to draw attention to the fact that in the preliminary report there are several very definite statements made which certainly do not suffer from this difficulty. As an instance, the conclusions with reference to ring-burners state: "As a matter of practical convenience, to deliver a sufficient number of B.Th.U. in a reasonable time without abnormal pressures, the gas used should be of a moderately high calorific value." It does not say "tested in the way in which we have made the tests here." It makes the bald statement which, of course, the present report completely disposes of. A little further down, it is stated: "When the gas quality is sufficiently reduced, lighting-back occurs with most ring-burners in common use; but the limit varies considerably with the design of the burner. It varies from 500 B.Th.U. gross to 400 B.Th.U. gross in these experiments." I could go on drawing attention to quite a number of conclusions in the first report. There is one in the summary of conclusions about low pressure incandescent lighting: "With gases of about 450 B.Th.U. gross and below, the control that it was possible to obtain by varying the consumption and aeration was not sufficient to give satisfactory illumination." I venture to suggest to the Committee that they should revise the first report in the light of the second one.

Mr. R. G. SHADBOLT (Grantham): I should like to confirm Mr. Duxbury's experience in regard to the two grades of gases, because I see evidences of incredulity, particularly with reference to the illuminating power from the gas containing the higher percentage of inerts. Of course, the percentage of inerts has nothing to do with it—it was the hydrocarbon content. This was clear, when Mr. Duxbury read the analyses, to anyone investigating the question of inerts.

The PRESIDENT: Where did you get your evidence of incredulity?

Mr. SHADBOLT: As the Irishman said, by the smiles I heard around me. Perhaps I might ventilate a little secret—even the table itself was not exempt. In regard to the slightly higher difference obtained in boiling water with the gas containing the higher percentage of inerts, my own experience is that, right down to producer gas, compared with a straight coal gas, you will get a slightly higher difference in boiling a given quantity of water per B.Th.U.

Mr. J. KELLY (Bridlington): In connection with the remarks of Mr. Abady, as legislation is pending and the Board of Trade's mind is more or less made up—

The PRESIDENT: Is that an assertion of Mr. Abady's?

Mr. KELLY: I understood he said that the Board of Trade had issued some report in which there were two points. One was to the effect that one B.Th.U. is as good as another, or almost so, and that gas of varying calorific power was of the same parity; and the other was that the question of inerts had almost been decided upon, and that they were to be limited.

The PRESIDENT: I should like to warn you against concluding that the Board of Trade have made up their minds on any such subject. It is quite true that the Board have received a report from the Fuel Research Board; but this report is not the report of the Board of Trade.

Mr. KELLY: I am very pleased to hear that.

The PRESIDENT: I think it is very important that this should be observed.

Mr. KELLY: I did not quite catch what Mr. Abady said; but I took it that the Board of Trade had made some pronouncement on the subject. I want to say now—because they may be making up their minds before this investigation is completed—that the whole investigation goes to prove the case for entire freedom from any limitation of the percentage of inerts. Had we not been more or less entirely free during the war, this investigation would not have taken place; and if the investigators had not been free, they could not have carried out the investigation in the way they have. The progress that has been made in the industry, under the freedom which it has had for a limited time, is an argument for freedom for all time; and I think it would be very inadvisable to restrict us to 12 p.ct., or any other percentage, of inerts, notwithstanding Dr. Davidson's remarks, which apply, I believe, to a very small percentage of the total gas supplied in this country—only that used for melting metals and for high-temperature metal work. The bulk of gas is not used for this purpose; and if it were necessary to have gas free from carbonic acid in certain specific cases like that, it might very well be left to partial legislation for the particular places where such gas is required. General legislation, however, should be for gas as generally supplied; and certainly it is not generally supplied for that purpose. For all other purposes, it seems to me, from the work of the Investigation Committee, that the percentage of inerts does not matter at all. Touching on what Mr. Duxbury said—viz., the dilution with air—he is merely taking in air primarily instead of secondarily; and it is not fair to compare the percentage of inerts put into a gas by mere admixture with air. That is not the same by any means as the percentage of inerts you would get by the manufacture of gas in the ordinary way and excluding the question of air altogether. It hardly touches, I think, the question of flame temperature or the parity of the B.Th.U.; it certainly will not touch the parity of the B.Th.U., because you are mixing air in one place instead of in another. But I do want to press the view now, that the industry should demand entire freedom from all restrictions as to inerts. It is absolutely necessary, in the financial interest of the consumers and of the manufacturers, that the industry should be free from every restriction; almost solely in the interest of consumers.

Prof. Smithells Replies.

Prof. SMITHELLS: I should like to refer particularly to the observations of Mr. Townsend, who has made some criticism of our procedure. We are perfectly delighted always to receive criticism as to any detail of our work. At the same time, I think the criticism he has offered is not well grounded. It amounts largely to this—that, if practical men (to use his own expression) had had charge of this investigation, they would have proceeded to do last year what the

Committee have only done in connection with the present report. He wishes for corrections to be made. Well, of course, practical men—especially those who are fond of declaring themselves as such—sometimes do the wrong thing first; and I can say that it would have been so in this case. You see, the Committee of practical men who are now investigating this subject—including Mr. John Bond, Mr. Charles Wood, Mr. J. H. Brearley, Dr. E. W. Smith (I need not enumerate them all)—felt that the right thing was to work with appliances as the consumer had them. They may have been wrong or right; and I do not wish to press the point too far. The whole matter was deliberately considered; and we adopted the course we did, not by accident, but by design. All this only illustrates what I have already said. Our reports are very much like showing our laboratory note-books. They show the order in which we proceed. They do not show the order in which we shall state our conclusions; and when the time comes to put before the public a complete summary of the work carried out by the Committee, I hope the order in which we shall state our results will be such as to satisfy all sections of the gas industry. Let me also say once more that, after all, this inquiry was not conceived with the notion that we ought to commend gas to the public. We had to make inquiries regarding the efficiency of gas in manufacture and use. It is unadvoidable that, in recording our progress, there will be facts set down which are under-stated, or would be under-stated if what we had in mind was merely to show gas at its best. It is equally true that there must be a good deal omitted which would be put in if our purpose was to advertise gas. And we know that these commissions and omissions may be abused by enemies. Those who are unscrupulous may take partial statements and use them to their own advantage. But we must take all risks of this kind. We must consider that we are out, not to deal with an unjust or an incompetent jury, but with a body of sensible people; and I myself have not the least fear that, either by the procedure referred to by Mr. Townsend or by the odds and ends of information included in or omitted from our report, we shall in the end suffer the least damage. I hope I have not expressed myself with any suggestion that we resent criticism; but I have very inadequately tried to express the idea that we are proceeding on a very carefully thought-out course, and consider ourselves justified in being prepared to take the consequences.

The PRESIDENT: While you are here and considering this subject, I would like you to send a message to the Gas Investigation Committee. Is it your desire that they should continue to pursue this subject as it is now being pursued? ["Yes."] I shall ask Mr. Wood to send to me on your behalf his reply to any questions. I promise you that the work of the Committee shall be pursued with all energy and endeavour that we can put into it.

Mr. H. E. BLOOR (York): May I just ask the question whether the Gas Investigation Committee's work came before Sir George Beilby's Committee? Did he know of the work the industry was carrying out, and take evidence for the industry?

The PRESIDENT: Every word that is reported to the Institution Sir George Beilby receives; and I know he gives very careful study to the subject.

Mr. BLOOR: I only wish to say that it is a great pity that the official report should have been prepared and submitted to the Government while the industry most vitally concerned has appointed an expert body to investigate matters, a solution of which ought to have been precedent to the presentation of the Beilby report.

The PRESIDENT: If we could order things that way, we should do so.

The New President.

The PRESIDENT: I have to report, from the investigation of the election papers sent in, that the voting has resulted in the nomination as President of Sir Dugald Clerk being unanimously accepted. [Loud applause.] Sir Dugald Clerk, I have very great pleasure in announcing to you that you have been appointed to succeed me in the presidency of the Institution.

Sir DUGALD CLERK: Mr. President and gentlemen, I am exceedingly grateful to you for the hearty way in which you have received the announcement of my election as President. I feel it a very great honour indeed. I am not professionally a gas engineer, but have taken an interest in gas manufacture for many years, and have had a good deal to do with the study of gas in connection with internal combustion engines. Incidentally, I also have had to do with Welsbach and other incandescent burners. It is a very great honour to elect one who is not after all one of your own body. I will do the very best I can in the interests of the gas industry, and shall endeavour, with Prof. Smithells, to uphold the standard of honour and truth, without merely advertising. The industry does not require that. All we need is that the truth shall be known; and the gas industry will stand higher than ever it did.

The PRESIDENT: I also desire to express our thanks to the Senior Vice-President, Mr. Thomas Goulden, and the Junior Vice-President, Mr. Thomas Hardie, for standing back one year ["Hear, hear"] to allow Sir Dugald Clerk to take up office.

Other Officers.

New Ordinary Members of Council.—Mr. H. E. Bloor, of York: Mr. R. E. Gibson, of Liverpool; Mr. Alexander Milne, of Aberdeen; and Mr. James Paterson, of Cheltenham.

Auditors.—Mr. S. Y. Shoubridge and Mr. E. W. Drew.

Hon. Secretary.—Mr. W. E. Price, of Hampton Wick.

The meeting then adjourned.

The Benevolent Fund Meeting.

At the opening of the session on Wednesday morning, the annual meeting was held of the donors and subscribers to the Benevolent Fund—the PRESIDENT occupying the chair.

The HON. SECRETARY (Mr. Walter T. Dunn) read the minutes of the last meeting; and they were confirmed.

The PRESIDENT: You have each had a copy of the annual report [see "JOURNAL" for May 20, p. 429]. Will someone move that it be accepted—if it be acceptable to you?

Mr. C. F. BOTLEY (Hastings): I beg to move that the report and accounts be accepted; and as one of the retiring members of the Committee, I am afraid I relinquish office with a sense of disappointment that we have not been able to do better for the fund. It seems very disappointing. It is not only here, but in many other institutions, that some of us, at all events, are not alive to the possibilities of life. With a big institution like this, apart from special donations and invested funds, we really do not raise sufficient subscriptions to keep ourselves solvent. The accounts do show a balance this year; but it is largely due to the generosity of one particular gentleman. I have hoped for many years that all the members of the Institution might have become more alive to the responsibilities of the Benevolent Fund, and that we might have a more adequate response to our many appeals.

Mr. D. T. LIVESEY (East Grinstead): I have pleasure in seconding the motion.

It was carried unanimously.

The PRESIDENT: Mr. Botley has voiced all that can be said. It is only a reiteration of the previous appeals for new subscribers. I am sorry, Mr. Botley, that you have a sense of disappointment. I was wondering whether you were gauging your disappointment by the work that the fund has done, or by the position of the fund generally. When an appeal has been made to the members before, and they have not responded, some had good reasons in their minds and hearts. Others have taken the responsibility of not helping the fund—the responsibility is theirs. I do not think that we should harass the subscribers who are here by scolding those who are not present. I think the fund as a whole is serving in a very large measure the purpose for which you subscribe to it.

Mr. LIVESEY: Is not Mr. Botley's position that the Institution should do more than it does to help those who are in need? That is as I understand Mr. Botley's statement. It is not what the fund is doing, but what it is not doing, that he complains of; and it occurs to me that his appeal

is made rather in the wrong place. He is appealing to those who are already doing the work; but it should be made to the larger audience who are expected here later on. I would suggest that when the whole meeting assembles, the President should make to them an appeal for the fund; and I think this is what Mr. Botley really desires. It is not to those who already subscribe, but to those who are not subscribing, that the appeal should be made.

The PRESIDENT: I think that is a very proper way of carrying out the appeal; and if you desire that the suggestion should be acted upon before the general business of the Institution programme is proceeded with, I will do so.

Mr. BOTLEY: I am fully conscious of the facts; and I hope no one misunderstood my remarks. As one of the retiring members of the Committee, I felt it was not out of place to offer a few remarks to the subscribers. We subscribers are doing what we can. What I want to do is to get at the whole body of members, so that the fund may be in a better position to deal with what may come along. I do not find fault with what has been done; but in an Institution numbering 800 members, there should be a larger proportion (allowing for those circumstances to which the President has referred) who would be willing to do something to put the fund in a far better position than it occupies to-day. Those here now are subscribers; and I am speaking to the converted. I do not wish to cast any reflection upon them; but I want to get at the other members of the Institution.

The PRESIDENT; What is it your aim is to do? Why are you feeling that you might do more? Are you not satisfied with the subscriptions and donations that are being given, or with the grants in aid of the dependants of those who have passed away or to those who have fallen on evil days? I should like to know more distinctly what is in your minds as the highest ambition that the fund ought to serve.

Mr. LIVESEY: I think the matter is perfectly simple.

The PRESIDENT: It is not simple to the ignorant. For the purpose of elucidation, I am professing absolute ignorance of your aims.

Mr. LIVESEY: I have read several of the reports of this particular branch of the Institution work; and there has been repeatedly a request made that more support should be given to the fund, as there was much more work to be done than the Committee were able to do with the present funds. I understand there are cases occasionally which have to be turned-down, simply because there are not the means to do as liberally as the Committee would wish towards those who have fallen on evil days. My suggestion was following up Mr. Botley's remarks that, seeing that we are the people who are doing something to help, we want to appeal to those who are not assisting, so that the Committee shall be in a position to deal still more generously with our fellow members or relatives who need assistance. It is one of the great calls of an association like this—a certain kind of freemasonry—helping those who need help; and if we can increase the funds with the aid of the general body of members, I think the Committee should do so, in order that they may be in a position to help more amply those in need.

The PRESIDENT: Do you know of any cases of particular hardship that the Committee have not been able to help?

Mr. LIVESEY: I only know from the reports that appeals have been made; and it is said the Committee have not been able to do what they might do if they had more funds.

The PRESIDENT: I do not want there to be any burden on your souls that there are people who should be dependent on this fund, who are going away unsupplied with some measure of help, because the Committee would pledge your credit rather than that applicants should be turned away harshly. The fund has been very much better supported by substantial sums being granted to be banked as capital to bring in some income each year to the fund; and while it is very easy from a benevolent fund to vote away money, the Committee feel that they have been able to help the cases that were honest in their application, or even in their recommendation. I do want everybody who recommends cases to feel the very grave responsibility of recommending to the Committee the granting of help from the fund. It was founded for certain particular purposes; and I think it is serving these purposes in a very large measure. There is no need for any unnecessary burden to be on your souls that the duty is not being done. Certainly, it could be done to a larger degree in these days, when the purchasing power of money is not what it used to be; and if we can get more subscribers, the Committee will continue to administer the fund as carefully as they have hitherto.

Mr. S. MEUNIER (Stockport): I should like to support what has been said by Mr. Botley and Mr. Livesey. Perhaps the stand that practically the whole of us take is not any critical view of the action of the Executive ["Hear, hear"], but the fact that from the whole of the members of the Institution of Gas Engineers throughout the country, a total sum of £249 is all that has been subscribed during the year; and that is by members now present. We should like to see steps taken to bring the matter more home to those who are not subscribers either individually or collectively—to show them the benefits of the fund, the good work it does, and the fact that much better work could be done if everyone was a subscriber, even of the small sum of 5s. per annum, so as to increase the amount of subscriptions from the paltry total of £249 to double, or treble, or even quadruple the amount. As the President has rightly stated, the purchasing power of money is considerably less now than it was before the war. Therefore, basing upon that very fact, the amount of subscriptions only goes one-half as far; and yet, instead of getting an increase, we are still sticking at about the same level. Can the Executive, in their wisdom, think over the matter, and see if they can make suggestions to the District Associations for the appointment—shall we say?—of a local charity representative, to try what he can do in the way of getting money? Whatever may be done, I should like to see that £249 become at least £1249 per annum.

The PRESIDENT: Are there any other suggestions?

Mr. J. BELL (Dumbarton): I propose that we defer discussion of this subject until to-morrow afternoon, when we shall be taking up the questions of status, salaries, &c.

The PRESIDENT: No doubt, it will be quite a possible additional subject to consider; but we shall consider it to-morrow with more intelligence if we have before us such suggestions as are being made now.

Mr. W. C. JACKSON (Neath): It appears to me that "grants to the number of fifteen have been voted by the Committee during the year," is not personal enough. We heard yesterday from an American friend how over there they go in for advertising facts. I do not think this is half enough of a personal appeal to the general members of the Institution.

The PRESIDENT: How would you put it?

Mr. JACKSON: I would suggest, as is done in the case of other charities, that we might say so many widows have benefited to the extent of a certain sum of money; so many men who have been laid aside through illness or some other cause have benefited to the extent of a certain amount—making such and such a total. That is my suggestion—that we might bring a little more personal element into the business.

The PRESIDENT: What do the members think of that? Are there any more suggestions?

Mr. A. MASTERTON (Edinburgh): Perhaps I might explain what is done in the case of the North British Association of Gas Managers. The annual subscription is divided into two. One portion is set apart for the ordinary requirements of the Association, and the other portion for the benevolent fund. This would be one way of reaching all the members of the Institution.

The PRESIDENT: I did not know that that was so.

Mr. R. BEYNON (Torquay): What limit is there to the application of the fund? Does it include the wives of senior clerks, or only the widows of gas managers or gas managers themselves?

The PRESIDENT: The beneficiaries are the widows of subscribers or children left in need owing to no fault of their

own—possibly cripples, either mental or physical—though in some cases help is extended to children of deserving past-members. In some cases, a grant is given to aged members, and after death it is considered that it can be continued to the widow or some daughter who has been left needy. Great interest is taken by the Committee in the investigation of the cases, without making the recipients of the benefits afterwards feel that they are being pauperized by the grant. It is always so easy to give away other people's money. It is given away by the Committee in a very careful manner. Of course, it is easy for people to continue to come with an open hand and receive your money, if you are foolish enough to give it to them in undeserving cases. I say that with all due regard to the investigations that we have to make. We do not want to publish the names of the recipients. I would like to say, however, that any inquiring member will be furnished with all the particulars; and we shall be much interested and helped by members taking a deeper interest, and a more particular interest, in the cases.

Mr. R. B. Anderson (London): If remarks like those were incorporated in the report, it might go a long way towards eliciting sympathy from members who are not subscribers. The report is indefinite as to what has been done. It refers to fifteen cases; but nobody has the ghost of an idea of the cases, and a little information of the kind that you have given in reply to the various questions would go a long way.

Mr. H. Kendrick (Stretford): It might also help if a brief description was given of the more deserving cases, without mentioning names.

The President: Exactly. If you confirm the election to the Management Committee of myself and Mr. Terrace (late of Grimsby, but now of London), we will promise to honour our re-election and election by seeing that these very helpful suggestions are made the best use of. Do you agree with that, gentlemen?

The election was agreed to, and the meeting of the Benevolent Fund closed.

The business of the annual general meeting was then proceeded with.

The Education of a Gas Engineer.

The President: I now have pleasure in calling upon Prof. Smithells to open a discussion upon the education of a gas engineer.

It is by the express wish of our President, and not on my own motion, that I am here to-day to open a discussion on the education of the gas engineer. We are entering on a new period of the world's work; we are reviewing everything—re-adjusting our ideas, and are preparing to go forward and do better. The President feels, I imagine, that it is timely that we should confer upon the educational needs of the gas industry; and I cordially agree with him. The gas industry has risen to the occasion magnificently during the agonizing experiences of the last four years. Its members might well plume themselves upon its efficiency and be tempted to say that they who have done these things have justified themselves and their ways, including their educational ways. But I do not think that is really their attitude. I think we are conscious rather of having passed through great anxieties and having had narrow escapes, and of feeling that we must secure ourselves for the future. Apart from all international considerations, we have great national questions to confront—in short, we are at a period in the history of the gas industry when no effort must be spared to improve our efficiency. The training of all ranks calls, therefore, for our most careful consideration.

I do not know where we shall find the man from whom we shall all be willing to take the law about the education of the gas engineer. We should want someone with a range of knowledge and experience hardly to be expected in any single person. Experience and achieved success in the practice of the industry, a wide knowledge of all the contributory sciences, familiarity with the practice of education, a strong sense of proportion, a wide outlook—all these would be required, and perhaps more. I make the enumeration chiefly to show that I am well aware of my own limitations and, may I say, of the limitations of others, and that I know I can only speak from a restricted range of knowledge and experience.

I do not propose to lay before you any detailed prescriptions for the training of your recruits. I think it will be more useful and much more within my powers, if I try to set forth some general considerations upon the whole question of education in relation to the profession of a gas engineer. If we can agree upon general principles, the construction of detailed programmes is comparatively easy.

The Theory of the Apprenticeship System.

In the first place, let us clearly recognize that there are two schools of education for industry—one is the works, the other the school or college, with its class-room and laboratories. I need hardly say that the predilection of of the Englishman is for the training ground of industry itself. The theory of the apprenticeship system is that a young man, and often a very young man, shall become attached to men of experience and from them learn the practice of his profession in all its phases from A to Z. The intimate contact and experience with the realities of the industry which are there secured at an early age are, I know, often considered to be of priceless advantage; and I have often come across successful men who would put what they call this early grounding above every other educational consideration. They speak indeed often in what is almost mystical language about the effect of this early training, as if it were the planting of a human being as distinguished from the transplanting. Many will attribute their success mainly to the tender age at which they were immersed in their business.

Apprenticeship is no doubt an excellent, and indeed an indispensable, system so far as it goes, if it is properly carried out. I do not know whether in any calling it can now-a-days be considered all-sufficient, but in some it may be nearly so. It is certain that in many others it is not sufficient. So long as industries were only arts, and depended solely on what we may call craftsmanship for their successful pursuit, they could be learned outright in the workshop. But when industries become, or are revealed, as applied science or applied art, and when their progress is seen to depend on the deliberate and successful application of scientific or artistic principles, we realize that their full pursuit requires that their members, or some of them at least, shall at some period and in some manner endow themselves with a knowledge of these principles. They cannot be picked up like craftsmanship; they are not knowledge which comes by imitation. Systematic study outside the workshop becomes a necessity.

I think we are all agreed about the practical side of training. We agree that it must be done in the works. We may seek, and wisely seek, that from the earliest days human beings should be taught to cultivate manipulative skill, and to acquire some proficiency in the use of tools. We do not want education to be all bookish; nobody should be allowed to grow up all thumbs. Manual training should be one of the strands throughout all education. When it comes to the special materials, appliances, and operations of a particular industry, we shall agree that no school or college can replace the works.

The Continuation Schools, which we are promised under the Fisher Act, may no doubt be to some degree specialized in their curriculum, and prepare pupils more directly for the particular pursuit they will have to follow in life. How far we may go in this direction I will not attempt to anticipate; but I must confess to being in sympathy with what appears to be the view of the working classes—namely, that this extended education must not be narrowly vocational—it should be aimed at developing a wide range of understanding and interest.

Scientific Principles and Practical Problems.

The particular question with which I am concerned is how we shall provide the knowledge of scientific principles and their application to practical problems. It is here that I and my tribe come into relationship with the industrial world; and it is here we are apt to come into conflict. On the one hand, we have the practical man impressed with a knowledge of the realities of industry, of the immense importance of the factor of experience, of the value of native talent and sagacity—what you may almost call moral qualities—of the futility of certain kinds of learning, and of the dangers of the eager theorist. You have this

practical man bent on getting what he regards as necessary from science on the strictest terms of economy in time, and with the least possible interference with what he looks upon as the real business of learning one's trade.

We, on the other hand, stand with our knowledge of science, with our experience of its power of furnishing humanity with new resources, with our desire that it shall shed its full light into every corner, and with the record before us of what it has achieved for industry. We are in danger, not I think of over-estimating what it has to offer, but of under-estimating how much there is besides science which is indispensable for success in industrial callings, and our tendency is, perhaps, to undervalue education which is inherent in the prosecution of the practical calling itself.

Every industry, and the gas industry among the number, can no doubt show examples of men who have by self-teaching equipped themselves with a remarkable knowledge and grasp of scientific principles. Such examples are very impressive; but I believe they have their disadvantage in tending to elevate into a prescription for all what is possible only to the very few. I think it is no exaggeration to say that at the present time you may see abundant examples in British industry of the insufficiency of self-education in science—cases where a knowledge of science and the power of using it have to some extent been acquired, but where want of the firm ground of a knowledge of basic principles is very apt to lead men astray.

The Need of Scientific Masters.

I think it will be generally agreed that the science teacher must come in to give his aid. And, of course, he has come in. But we must go further. I think the time has come when the gas engineer must recognize that the modern conditions of his industry demand a very much more extensive and thorough scientific training than has hitherto been customary. It is not right that I should prophesy who are going to be the highest powers for good in advancing the gas industry—the man of affairs, the manager, the engineer, or the chemist. But I think that no one can doubt that the industry does need, and will need more and more, an accession to its ranks of men who are really scientific masters of their profession. The science that ministers to your calling is not less comprehensive than that required for any other branch of engineering. The mechanical, civil, and electrical engineers feed their profession with a constant stream of recruits who have had a three or four years' course at a University; and I feel certain that gas engineers should come into line. This will no doubt seem a large demand; but I am satisfied that nothing less will suffice.

The view that all essential knowledge of science for the gas engineer is to be obtained in spare hours of the working day by study, by attendance at evening classes, or by short intensive courses, cannot be entertained. I have no desire to belittle such forms of education. They may be made good and useful so far as they go; but they cannot possibly provide all that is needed. I would most earnestly entreat the members of the industry not to be beguiled by half-measures, but to make bold educational investments. I do not look for a sudden change of attitude, nor do I expect to exercise much influence on a great many individuals. I do not foresee a rush to the Universities; but I do sincerely hope that those who have the faith and courage will make a beginning upon a real professional education conformable to the needs of the industry and the present state of scientific knowledge.

Ability of Pupils an Indispensable Condition.

Let us at the Universities at least be entrusted with a certain number of young men of real ability, and see what we can make of them. I say young men of real ability because that is an indispensable condition. You must forgive me if I insist on what may seem to many to be the most obvious consideration; but the fact is that during my teaching experience I have often been very much surprised by the extent to which these considerations are ignored. We have been greatly embarrassed in the Universities by being called upon to train unsuitable pupils; and I do not think I am exaggerating when I say that a great many people have no adequate appreciation of the intellectual standards that are necessary. We are not in the position of those who merely supply a commodity and sell over the counter, as it were, as much as may be desired to any purchaser. Our business is to instil ideas and develop aptitudes; and we cannot do this unless there is the receptive mind and the latent intellectual power. I can assure you that it has been by no means a rare experience for me to find myself regarded as a delinquent by the parent of an unteachable student, because I have as it were not delivered the goods. We do not deliver goods. Education is not a process of filling empty vessels; it is a process of growth and training; and we must have adequate native talent to work upon.

Having regard to the conditions I have set down—the demand for adequate time and adequate talent—I say again that I have no expectation of our being crowded out with pupils. They will bear a very small proportion of the whole personnel of the industry. If it be asked why I have not addressed myself rather to the education of the majority, the answer is, first, that it is because I believe the primary necessity for every human enterprise is to have educated leaders; and, secondly, because, as a University teacher, my experience has lain among these problems of higher education for industry. I am very anxious, however, not to appear indifferent to the education of all ranks of the profession; and I should be very sorry if I gave the impression of being in any degree supercilious about the very fine work which has been done, and will I trust be continued and extended by evening class instruction. I have had occasion to know what excellent and devoted service has been rendered in this way to vast numbers of the rank and file of the industry.

Educate Consumers.—Tribute to the "B.C.G.A."

One of the serious duties of the gas industry is to educate the consumer, to give him (and I may perhaps say especially to give her) some common-sense knowledge of the use of gas appliances. It becomes very important, therefore, that everyone in the industry should be instructed as far as possible in the rationale of his work. I should like to say, incidentally, how very highly I esteem the educational work which has been promoted and carried out by the British Commercial Gas Association.

The Period for University Training.

Before I conclude there is only one more question I desire to raise. My remarks have amounted in the main to an appeal for a thorough scientific training of gas engineers comparable to that already in existence for other kinds of engineers. If this is conceded, there still remains one very important question to decide—viz., at what period shall this University training take place? Shall it immediately follow upon the school years, or shall it come after some preliminary experience of the works, or shall it be split up and alternated with experience in the works—the so-called "sandwich" system? This is a debatable subject, by no means as simple as it may appear.

I imagine that the great majority of practical men would be inclined to decide at once in favour of some works' experience preceding, and perhaps alternating with, University study. The advantages expected from this course are threefold. In the first place, the young man will be confirmed at the outset in his profession. In the second place, he will be led to see the kind of problems he will have to face, and the kind of knowledge he will need to solve them. In the third place, it will give him so much more interest for his theoretical studies. It certainly should be so. But believe me there is another side to the picture with which experience has made me very familiar; and I can express it under three heads, to be set against what I have just put down.

In the first place, then, an early taste of the real business of a works often fires a young man with great impatience to go on with it, and a corresponding reluctance to betake himself to studies. In the second place, he often gets a totally wrong view of the kind of knowledge that he will most need. In the third place, this early impress of things practical will detach his interest for things intellectual. I assure you again that I speak from experience.

I know no more trying and intractable type of student than the young man who comes to a University thinking that he knows how to distinguish what is going to be of use and what is not. He is a familiar figure to every professor of science. You are talking (say) about the principles of chemical equilibrium, as you must talk if you are to give mastery of what goes on in gas manufacture. You cannot bait every hook of principle with the attractive substance of an immediate practical application. So there your initiated student sits a passive resister to what he conceives

to be your superfluities of knowledge. A little later perhaps you mention water gas. Then you see the difference. There he is all alert, eager. Real business at last, he thinks—too late, alas! to be understood, from his neglect of what has preceded. What seem superfluities are often the hidden foundation of serviceable knowledge and the most essential tools for practical success. This young man is no invention. He is, if you will allow me to say so, the son of his father. His father, whose name is legion, is the man with a half-hearted belief in scientific knowledge; the man who has a certain distrust (not altogether unjustified, as I have always admitted) of professors; the man who has the idea, wherein he is utterly mistaken, that it is an easy thing to go straight to the knowledge you need, and who thinks that you should be able to supply educational garments for all figures, if not ready made, at any rate at very short notice. He wants his milk all cream; and he is too often the ready victim of educational impostors who offer him such. I weary you perhaps with these reiterations; I fear I may even annoy you. But I speak in no mood of idle banter or bitterness. I am endeavouring, not for the first time, to impress upon you a view of the educational pitfalls that are a special danger attendant upon the British temperament.

On the particular point at issue—that is, whether works' experience should precede, follow, or be alternated with University study—I have an open mind; for my experience does not decide the question for me. On the whole, with all its risks, I am inclined to think the best policy for the present is to give a short period of works' experience first. But this is a subject on which I should much wish to hear opinion expressed in the discussion.

Here I will leave the subject, very conscious of the inadequate treatment I have given it. If I have stimulated thought, however, I shall have achieved my main purpose. It is now more than thirty years since I began to teach science. At a very early period of my life I became deeply impressed with the view that the industries of this country needed a strong influx of science; and I hoped to take part in training a generation of young men who should take with them into their industrial calling a much greater equipment of scientific knowledge than their fathers before them. Throughout my life I have bent myself to this work; and you will understand that in these later stages I am often inevitably led to reflect on what it has all come to. I cannot say that I am ever intoxicated by any sense of triumph. The feeling that science must flow into industry has undoubtedly deepened. There is a stronger public opinion in favour of it, and fair words abound. The educational organization provided has been considerable and, in some instances, very liberal. But there still remain very much reluctance and timidity; and a self-styled practical man of the more blatant kind can still appeal with hope for some applause when he seeks to evade the companionship or criticism of science by using worn-out aphorisms about an "ounce of practice," and by sneering allusions to the "academic."

I hope that the ordeal through which we have recently passed—when again and again all we hold precious in life has been saved to us by the close union of high science and sound practice—may prove to have given an impulse that will lead to a better understanding and a closer co-operation between the two worlds of labour and learning. I am no believer at efficiency at any price. Our chief enemy in the war had indeed in many particulars made himself efficient in a very high degree, and largely so by carefully designed educational measures. But in doing so, he lost his soul; and he has, on his part, undoubtedly given science a bad name. We are not likely to travel the same path; and I am sure that no reflective man will say that any educational measures we undertake need be fraught with risk either to our peculiar practical genius or to the moral qualities of our race.

The PRESIDENT: I want to save your time by voicing for you our hearty thanks to Prof. Smithells for bringing this subject before us. He will quite understand that each speaker expresses thanks to him even if he does not reiterate it every time he gets up. The discussion is now open.

A Life's Experience.

Mr. HARRY E. JONES (London): As perhaps the oldest practising gas engineer among you—having belonged for many years, not many years ago, to the Education Committee of the Institution of Civil Engineers, with the late Sir William White, Chief Constructor to the Navy, as Chairman—I may be allowed perhaps to give you a few words, from a life's experience, on the question of the education of the gas engineer. To begin with, a gas engineer takes in his daily routine a distinctly chemical process; so that he must provide himself with sufficient science, not to be a thorough chemist—that is a business of its own—but to grasp the radical principles of the combinations of most of the ordinary elements of Nature which surround the particular business. Before he can do this, however, I agree with Prof. Smithells that the best way to teach our young men is to let them enter the workshops, and especially mechanical workshops. That was my training, and perhaps that is why I stick to it. I remember that the mechanical workshops of the big railways that I went into were to me a paradise, full of beautiful problems, full of delightful solutions. There were large tools and small tools; and the heavy tools and the ingenious smaller tools altogether filled me with admiration and made my days not days of hardship or work—although at first I tried to keep on from 6 o'clock in the morning till 6 o'clock at night. That has rather broken down; but even my days in the workshop were not hardship, they were delightful. I always insist nowadays, before appointing an engineer—for I have passed the stage of seeking appointments myself—that he should have had a mechanical training. It may be that he has been a foreman or a blacksmith; but he knows all the different problems that are constantly cropping up. Mechanical engineering lies at the root of all engineering. The chemist cannot proceed on any scale without having apparatus that demands the services of the mechanical engineer, whether he is a tinman or a lead worker or a man who makes the large tanks of steel or iron which we have to use. The civil engineer cannot construct the Nile Dam or drive a tunnel through the Alps without the mechanical engineer, because he must make the tools for the contractor, and he must make those delightful instruments of precision with which he proceeds to bore through a mountain and meets his companions on the other side within a foot, after having travelled through miles of solid rock. Therefore the mechanical engineer lies at the root; and I hold that this is what we must insist upon. Many of you who have passed through a big contractors' works know something of rolling, planing, shearing, &c.; but you cannot stop at that. In various addresses I have tried to point out that I think there is dignity in our profession. We are second to none. If you are not something of a civil engineer, what is the position when your tanks and gasholders go wrong? You will not know what to do with them. If you are not a mechanical engineer, when your exhausters and pumps and various apparatus break down, you will not know exactly what to do. If you are not something of an electrical engineer, you will be far behind. We have heard a lot against electricity at various times; but it is a most convenient force on a gas-works, and it is often surprising that most of us know very little about it. As a matter of fact, even the great professors cannot tell us much about it; and one of the curious things is that it will go through a solid rock and come out at the other side. I have endeavoured to show you what is uppermost in my mind. When I was a young man, I went for a short time to the laboratory of Dr. Medlock, sufficiently long to know what common salt was and the difference between air and water. But it was useful to me, and it has helped me since to understand some of the lessons which Prof. Smithells has put before us from time to time. When I had a works large enough, I had to obtain a chemist; and I got a gentleman who was one of the ablest chemists that we have. This was 45 years ago; and he helped me because I thought my own knowledge of chemistry was not sufficient. You must have chemistry; you cannot really live on the earth without chemistry. It enters into the air that we breathe, and into daylight, sound, heat, and light waves. They are all delightful, and you must know something about them. But you must know absolutely a good deal about mechanical engineering. I have some claim to speak about this, because for some years I was one of the Governors of the People's Palace, Mile End—now known as the East London College, and well known to Prof. Smithells, I am perfectly certain. The problem is, how can you stop your boy wasting his time? You must have a good sound education to begin with; and that, fortunately, is now provided by the nation. It is fairly good, but not quite sufficient. Our boys should then, I think, go into the workshop and learn something of

the various operations, how to make steam and fashion iron, to forge it under the steam hammer, and how to plane it. Then he should go to college before it is too late, to learn what are the principles that underlie all this work. But he will never grasp it properly until he has had a higher education in science.

Are the Teachers at Fault?

Mr. F. W. GOODENOUGH (London): Prof. Smithells spoke of the difficulty we should find in discovering a man from whom we should all be willing to take the law in regard to the education of a gas engineer; and he catalogued a list of qualifications which certainly are rather exclusive. But I feel sure that you will all agree that Prof. Smithells, more than any man, is acceptable to us in that place. The first qualification he catalogued is the only one, I think, that we should say he did not possess, and that is experience in successful practice in the industry. But I am not at all sure that we should say that this is a necessary qualification for the Director of Education, as we should call whoever we selected to lay down the law for us as to education. Practical experience in the industry is wanted in the teacher rather than in one who plans the whole of the scheme. The other qualifications—wide knowledge of contributory science and familiarity with practical education, a strong sense of proportion, and a wide outlook—we all know how fully they are possessed by Prof. Smithells; but I do think that this particular qualification of experience is probably what is so badly wanting to make the educational system more acceptable, more interesting, and more attractive to the student. Prof. Smithells has spoken of the reluctance and timidity of parents to send their sons for training in science. He has spoken of the early days of business creating a reluctance towards study on the part of the student; he has spoken of the student who sits as a passive resister while pure science is being taught as distinct from the practical application of what he is interested in. But I put it to the Professor, does not that really constitute a criticism of the teaching that is given? If the teaching of science in the schools and Universities is not so planned and carried out as to be really attractive to the student right the way through, if the teachers and professors cannot make students right from the beginning feel that the whole of what they are going to be taught is absolutely essential and vital to the profession which they are going to follow, then I suggest that the fault is not only with the student, but it must lie somewhere with the teachers. This is the principal thought that occurs to me in listening to the Professor's most interesting paper. At first he spoke of the great need of our improving our efficiency; but later on he began to falter somewhat on the subject, and said he was not a believer in efficiency at any price. I do not think he need fear laying too much emphasis on the need for efficiency at the present time, either in the gas industry or any other industry. I do not think we need be alarmed by the German example. It was not because of their efficiency, it was because of their soul being wrong, that they went wrong. The Professor says that, in becoming efficient, the enemy lost his soul; but I would rather say that while becoming efficient he lost it. It was not because he was efficient, but because he was evil, that he went wrong. So do not let us lose faith in efficiency; do not let us lose our zeal for efficiency, because the most efficient nation—at any rate, they claimed to be the most efficient nation, though I am not at all sure that they were—went wrong. Because the most efficient nation went wrong, that is no reason why we should not try to go right in the main; and I would ask the Professor whether he is satisfied that there is as much enthusiasm for, and faith in, industry on the part of the professors and teachers as they would wish us to have for and in science, because if there is not the same keenness for creating the right material for industry on the part of the teachers, they will never get the reciprocal enthusiasm of the students. I think we still suffer from the unexpressed—perhaps even the unconscious—contempt of the professional man for industry. The "nation of shopkeepers" is still regarded as a reproach, although Napoleon, who called us a nation of shopkeepers, said that no man of sense ought to take any offence at being so described. Is it not, too, because there is a tendency to limit the meaning of science to the science of things, and to forget that there is a science of men as well? Science, after all, is only organized knowledge; and there is a great deal that needs to be taught to those who are going to take a leading place in industry of the science of management, the application of psychology in management, and in the training of staffs and in the direction of salesmanship and so forth, to which the Universities so far have given very little attention. I think that if those who are planning and carrying out our educational work will bear in mind that science has a wider interpretation than merely the science of things, and that there is a science of men, the science of managing, that needs to be taught as much as the science of things, then we shall get a more valuable educational curriculum and much greater interest on the part of the students who take part in it.

The Merits of Theory and Practice.

Mr. PERCY GRIFFITH (London): I am interested in this subject on several grounds with which I will not trouble you; but I hope to show that my interest is common with that of all of us here in the room. Prof. Smithells has dealt with this question naturally from the professorial and scientific point of view; and I think it is extremely appropriate that in a body of practical men this point of view should be presented with the utmost emphasis. I think, further, that the problem which the Professor has introduced to us as being one of theory *versus* practice is rather more one of chronology, or rather, I should say, history. The great majority of us in this room have had rather more than thirty years', and some forty years', experience of gas manufacture. With these I have every sympathy, or rather I would put it the other way round, and say that from them I ask sympathy with myself in the fact that I have not been in the fortunate position of having had that practical experience. I have only had experience as a consulting engineer; and I want to say at the start that it is very much easier to design a gas-works than to make gas. The question, however, does become very serious as to the qualifications required of those whose business it is to make gas; and I think the Professor has brought a view before us which we must seriously consider at the present time. Let me just briefly suggest to you a comparison in your own minds—and most of you have sufficient experience to compare the position to-day and thirty years ago. It so happened that I, like the Professor, entered my profession about that time; and I picked up from my table this morning two books which will illustrate the difference in the position of the engineering profession as a whole, but more particularly that of the gas industry. When I was at college I was given Molesworth's "Pocket Book" as the *vade mecum* to the profession; and I had the impression given to me—afterwards corrected—that I should find therein a solution to all the problems that would arise. Now I have on my table another book. I need not name it; but I only call your attention to its bulk, and suggest to you that that represents the increased amount of information, or the proportionate increase in the amount of information, which we engineers have got to acquire before we can be efficient, as compared with the position thirty years ago.

The PRESIDENT: Is that edition the last one?

Mr. GRIFFITH: It is dated 1911.

The PRESIDENT: It is very much bigger now.

Mr. GRIFFITH: My point is sufficiently clear, I think. Does not that justify the professor's claim that we have got to dig and get into this knowledge side, apart from experience. Now let me, in passing, just refer to the fact that theory *versus* practice was just as much a subject for discussion when I was starting as it is now; and it was impressed upon me that I must learn the practical side, and that the theoretical side did not matter so very much. The result is that I am a man of that period. The Institution contains a very large proportion of men who started more recently, and some who have started quite recently; and it is for their benefit I think that we, who have had the experience of only practical knowledge, should tell them that they will not be equal to the demands of the present time unless they put theory in with practice. But what is theory? The popular impression is that theory is merely a speculation which is put out in a form of hypothesis which is subject to proof by the practical man. That is not the true definition of theory at the present time. Theory really means scientific knowledge based upon past experience; and the proportions that I have illustrated in these two books represents the increase in practical experience which is available to all of us at the present time. It is on this experience

that the younger men have got to build the structure of their efficiency and carry this industry to the heights which are possible to it. Therefore, I want very strongly to support Prof. Smithells' point as against the popular impression that practical knowledge is worth a great deal more than scientific knowledge. As a matter of fact, they have got to be learned equally. I am not going to put scientific knowledge in front—except, perhaps, chronologically. A young fellow has got to take his science early for this reason, that when he gets past (say) 30 years of age he will find science rather troublesome. He can take it young; but he cannot take it afterwards. And so I urge that in the life career of the gas engineer he should start early with science. Of course, practical knowledge must follow; and I quite agree with the suggestion that it should be dovetailed in as far as may be. The theoretical and the practical knowledge should be dovetailed in as much as possible; but you must not forget that unless—and you all know it as I know it—you start learning your science very early, you do not learn it at all, or, if you do, you learn it backwards, and it is a very tough job. Therefore, I think we have got to alter our views. We are growing old. There are other men to take our place who are coming on, and they have a very different outlook on the profession to what we did. But we want it to be a very much better impression than we had, and a more efficient one. I hope I have the aid of you all here in strongly supporting the Professor's claim that in future we must put more science into our knowledge of gas manufacture, and the combination will then give us a chance of attaining the advancement of our profession and the advancement of ourselves in which we are so interested. To-morrow, I am told, we are to be invited to discuss another aspect of the personal side.

The PRESIDENT: And I want that subject left until to-morrow.

Mr. GRIFFITH: I will not refer to it. I only want to say this, that the question of qualifications and education will, in my view, arise as the starting point for that subject, and so I am asking you to pay the utmost attention to what Prof. Smithells has said here, and that, when you come to ask for a *quid pro quo*, you will have your *quid* in your right hand to offer for what you expect to get. The methods by which this education should be given, and, what is more important, the methods by which it should be acquired, are matters which the Institution as a body might take up in a thorough and comprehensive manner. I do suggest—and I think I shall be strongly supported here—that in any investigation of this subject there should be adequate representation of all interests involved in our profession—the technical, pure and simple; the practical, pure and simple. A combination of all these interests can be brought together, I am sure, by the Institution—*i.e.*, the very best of all branches in the profession can be brought together by the Institution; and I feel confident that, if the leading men in the various sections do come together, this question of the necessary education of the gas engineer will be advanced on practical lines to which no one member of the Institution can object, but which every member will, I am sure, ultimately be very grateful to the Council for dealing with in a sensible, comprehensive, and practical manner.

Mr. J. P. LEATHER (Burnley): I should like to add a few words on one practical point. Prof. Smithells has referred to a matter upon which he himself says he has an open mind—viz., the order in which the gas engineer should take the various parts of his education—*i.e.*, as to whether before his college training he should have some practical experience in a works. There is a great deal to be said for a portion of the practical work coming early. I say this because I had in my youth a length of time in practical work before going to the college. I had been brought up on a gas-works, and as a boy had played at being a gas engineer before I went to school at all. Consequently, I had an interest in gas engineering which enabled me to understand what was required of a gas engineer when I got to college. If there is too long a period in the works before going to college, then we come across the difficulty which has been mentioned by Mr. Griffith, of not being able to take in purely scientific training so well as when we are younger. It struck me when Prof. Smithells was reading the paper—although I had read it before—that there was a good deal of meaning in one expression—viz., "the young man who is the son of his father." If the father is a gas engineer, or if the gas engineer under whom the young man has some portion of his training—

The PRESIDENT: His godfather.

An All-Round Education Necessary.

Mr. LEATHER: His godfather in regard to his profession—is not a man who has a keen interest in pure science, then the young man is likely to be of the type which Prof. Smithells does not like to have thrust upon him—the one who is always looking for the practical side and the £ *s. d.* side of the question. This brings me to one more remark that I want to make, which is that I think science, or, as Mr. Goodenough has called it, the science of things, is not the only part of education. Prof. Smithells is, I believe, essentially interested in that part of education; but I think he will agree with me that education should be far more than that. The education of a gas engineer should include an all-round education, an education which embraces history—that which brings the knowledge, or helps on the knowledge, that Mr. Goodenough has spoken of as psychology—a knowledge of the world in general, a knowledge of the arts, and a knowledge generally of everything that constitutes British educational culture. A man who has this wider educational knowledge is more likely to be a man who will be able to manage a business. Managing a gas undertaking means managing things to which Mr. Jones has more specially referred, and it means managing a great number of different kinds of men. We have three classes of people to deal with: We have those who are working under us, those who are over us and who want as much management as those under us, and the consumer—the most important perhaps of all. To have all these qualifications certainly is a very great matter; and it is certainly difficult to find anyone who has them in equal proportions all round. A man may have to be a mechanical engineer, as Mr. Jones has said; but some men will excel more in one branch of the work than another. Very few will excel all round; but they must have that wide outlook which enables them to work in with those who fill up their deficiencies in those items in which they may be deficient. I just want to comment again upon the point on which Prof. Smithells says he has an open mind, and to suggest that a man must have some acquaintance with the practical affairs of the works in order the better to understand his education. It would be better if he had a little knowledge of men, because that more fits him to take in his college education. My own advice to young men that I have had to deal with has been that they should pass a short time in the works, commencing with actual manual work, dealing actually with machinery and with men, and mixing with the men. They know then, from the start, what they have to deal with when they come to be set over these men in later years; and during this time they should do all they can to keep up their knowledge of theory by such things as evening classes and so on, and then have a course at the University.

Mr. S. B. LANGLANDS (Glasgow): The point is, I think, that we have lost sight of Mr. Young's "black eye." The point is this. The result in education is not what is given us, but what we have to fight for. I think you will admit—and I hope you will forgive my being a nationalist—that we in Scotland know something about education. And we have had to fight for it. The men who have made-good are the men who have fought for their education. There is too much free education, and free this and free the other. University education is all very well; and you are inquiring where it is to be fitted in. Prof. Smithells asked the question directly; but if you are going to molly-coddle a boy and to say that there has been such a strenuous day that we cannot ask him to stop at night to work, it is very awkward for the boy. With the coming of the 44-hour week—because there is no doubt it is coming—there will be more than ample time for education for those who want it and are willing to fight for it. I hope that, if it does come, the point of all-round education will rise to the top. What will bring it to the top, however, is not altogether Universities, but a full use of Technical Colleges, and more especially Continuation Classes to start with; and then there must be real co-ordination between teacher, education, and practice.

Breaking Down Prejudice.

Mrs. M. A. CLOUDESLEY BRERETON spoke briefly of the significance of the undoubted fact that, since the war, even

the ancient English Universities were actively encouraging their men with suitable qualifications and the necessary inclination to study the humanistic, as distinct from the scientific and technical, side of trade and commerce. She instanced the breadth of the course planned, and the latitude allowed to the students who followed it, in the Cambridge degree, which embraced international history and economics. This tendency, slight as it is perhaps at present, of the older Universities to consider trade and commerce at all, pointed, she considered, to a breaking-down of the "spirit of contempt" until lately common in our older seats of learning for things commercial.

The PRESIDENT: Mr. Hardie, I hope you are not going to provide a prophecy of a 44-hour week or anything of that sort.

Mr. THOMAS HARDIE (Newcastle-on-Tyne): I do not want to prophesy; but I must say that I am very much in agreement with Mr. Langlands in this respect, that I think we can all determine what the gas engineer wants to learn. The question is, how is he going to learn it? Are the men who are entering the gas engineering profession of the class that can afford to spend six or seven years in going through the workshops, and then through the University course? I do not think they can. They are mostly sons of their fathers; and, unfortunately, these fathers are not able, if they have more than one son, at any rate, to allow them to spend such a long time before they are earning a living. The young men who are entering the profession are looking for a salary, and they want to know how they are going to get the salary, and they want to get as quickly as possible into some sort of position where they will be earning a salary. I do not think it can be done by first going through the engineering shops and then to the University. The man, after he has got out of the University, has to start afresh. There are very few gas-works prepared to take men direct from the University at a salary which they ought to obtain except in some special position—we will say, perhaps, as a chemist. If a man is trained as a chemist and not as a gas engineer, he is unable to control men; so that I think the better way for the education to be framed is for the youth to go straight on with his education. Let him get all the knowledge he can before he enters the works or the shops. If he takes engineering at the University—the Universities are all now fitted with good shops—and he then goes into the works with some knowledge of practical work, and if he can continue it he can much more quickly get into a position to earn his living. I think myself that is the proper scheme to adopt, because we want the men who find it is more and more difficult to spend six years at the start before earning a living. They want to be able, as soon as possible, to get into positions in which they can earn really good salaries.

A Good Word for the Scotch Systems.

Mr. D. T. LIVESEY (East Grinstead): I was hoping that Mr. Langlands, who comes from Scotland, would have had something to tell us as to how they do things there, because I think we have something to learn from the Scotch system. I had the good fortune to get a son in a Scotch works; and I find this was the system there, which we in England might do something to follow. He goes into the shops and takes two or three years, having the advantages of the evening classes at the technical schools while he goes along. Then he has the opportunity of leaving the works for six months and going into the University, and taking three courses in succession in the University for his degree. At the same time he is allowed three months off his apprenticeship for every six months he spends in the University, and in this way they sandwich the theoretical with the practical. It seems to me a very commonsense way of doing things; and I think it accounts to a large extent for the fact—I am not a Scotsman myself, but I do envy the Scotsmen—that you find Scotsmen all over the world occupying positions because they take theory along with practice. I think a system of this kind is one which is worthy of consideration.

Advantage of Combined Practical and Theoretical Training.

Mr. ALEXANDER WILSON (Glasgow): The Professor only referred to Englishmen. I noticed he did not refer to Scotsmen; but perhaps he thinks the Scotsmen can get there all right. I am very glad that Mr. Langlands raised this point with regard to evening classes. It is really everywhere in Scotland the case that, when anyone wants to get on, he goes and obtains his practical training and carries his theoretical training with him at the same time. I think when they obtain that they get not only a practical education but a theoretical education—they get more, they get a wider outlook altogether. I do not know what most of the experience has been, but I know that my own experience over a long period of years has been this, that where you get University trained men, in many cases you never get them trained in such a way that you can make use of them in really responsible positions. [Cries of "Oh."] Wait a minute—not to the same extent that you can if a man is practically and theoretically trained at the same time. There are men who can take responsible positions; but they do not seem as if they have the same faculties—the faculty in the way of taking charge. This has not been trained in them while they have been in the University. I think there is a want in this way; but so far as the training of specialized men is concerned, University training seems to bring them up to the very limit of perfection. For general work, such as the charge of the gas-works, where a man requires to have a general knowledge on all questions, I must say that my experience has been that a University trained man has never had the same chance alongside the man who has been trained with a real practical training and a theoretical training at the same time to get into a really responsible position which he can take up and fill with advantage.

In Favour of the University Training.

Mr. THOMAS GOULDEN (London): I do not know that there is anything to add on this subject; but I do feel this, that gas engineering is getting more and more a scientific profession. We have had reports lately, and we have had to receive reports from other professions; and every day that goes on, and every week, adds to the necessity—it is borne in on all of us—of science being the groundwork of our practice. I agree with Mr. Hardie in a great measure with regard to the ability or otherwise to take a University training. I am quite sure that in a great number of cases it is not possible, desirable as it is. That it is desirable, I am quite sure, if it can be encompassed; and to those who can encompass a University training I certainly should strongly suggest that the proper time is immediately after the school education—for this reason, that there is nothing that puts one back more in a course of studies than a break. If there is going to be a break for any period, for taking up the elements of mechanical training at the works or the general routine of the works for one or perhaps two years and then return to school studies, the bulk of the school training is forgotten. It would be a great handicap to a young man in starting on his University career. I disagree altogether with the statement that a University training does not fit a man for the management of men. On the contrary, it struck me that there was one notable omission in the paper. Mr. Goodenough voiced the omission, possibly unconsciously, when he mentioned the word "humanity." The proper study of mankind is men; and if any man ought to make a proper study of mankind it is the gas engineer, who has to deal with a great variety of classes, especially on a large works. Where do you get the opportunity given to the young man to find his level among his fellows more than in the University? He has got his classes and his recreation, his officers' training corps, and all sorts of opportunities outside his scientific training for finding his level and making associates and forming his character among those in whose society his future life lies. He makes life-long friends; he makes his character there; and he learns what is commonly called the game of "cricket." He learns how to play fairly with his fellow men; and that is a very great advantage to him. One particular thing in Prof. Smithell's paper was the necessity for developing a wide range of understanding and interest. Now, we do know that. We have our science; and surely we must be able to apply our science better if we know our groundwork in it. I have had a long experience now of gas-works and gas manufacture; and I have always regretted that my knowledge of pure science was not greater than it is. It has been a handicap, and we all feel it is a handicap to us that we have not that theory which it is so desirable to possess, which so few possess, and which it is not given to the many to possess. I quite sympathize with

Mr. Griffith in one thing—that it would make his work much more interesting if he had become a gas engineer. I think it is particularly fascinating that we should not only design a structure or a piece of plant, but that we should work the plant which we have designed, the child of our own creation, under our charge, and be able to watch its working. To me it is always one very great pleasure in my work as a gas engineer to have the whole thing right through from its very inception to its working. We want to be able to go through the gamut of the whole thing. But to do this we must have a knowledge of chemistry; we must have our draughtsmanship, and a knowledge of the whole of the processes. It has always been a source of regret to me that so many engineers have to depend upon contractors for their drawings. I should like to see every engineer in our profession thoroughly capable of carrying out his own work and putting it out to the contractors himself. I think it is a great blot on the gas engineering profession that there are a very large number who do not put forward their own designs, but leave them to the contractors. We want the very widest possible knowledge; and let us take every possible means of getting it.

Prof. Smithells Replies.

Prof. SMITHELLS: I think you will agree with me, Mr. President, that your object has been achieved. When you asked me to prepare a short paper, you did so in the hope of provoking a discussion on the question of the education of the gas engineer; and I certainly have been gratified in listening to the speeches which have fallen from the various members in the course of the last half-hour. A great deal has been said that tempts one to a further speech; but I promise you that the temptation shall be resisted here, and that anything I have to add in reply to the criticisms which have been made shall appear at a later date—possibly in print. I was much averse, I may say, to having the subject brought in at this early stage of the morning's meeting, when I know that so many people were more anxious to hear the more technical matters that were on the programme. I will only just say this, that I professedly, when speaking on this subject, looked at it from one point of view; and I hoped that others would look at it and speak on it from fresh points of view. This has happened; and with a very great deal, if not all, that has fallen from the speakers I am myself in hearty agreement. I have only to thank you very much for the patience with which you have listened to this discussion.

A Message from France.

The PRESIDENT, at this point, read the following message from the President of the Société Technique du Gaz en France:—

From M. Rouland, President of the Société Technique du Gaz en France, to Mr. Samuel Glover, President of the Institution of Gas Engineers:

> I send to the distinguished President and members of the Institution of Gas Engineers an expression of my best wishes for the success of the meeting following the victory of the united efforts of the Allies.
>
> (Signed) ROULAND.

The message was received with loud applause.

The PRESIDENT: From the way in which you have received this message I take it that you desire to send to M. Rouland and the Société Technique a message from this assembly. I am ready for it.

Mr. C. E. JONES (London): I suggest, Mr. President, that it might be left to you, sir. We are very desirous of sending them a very cordial message.

The PRESIDENT: The message shall be sent.

Report of the Refractory Materials Committee.

Mr. A. E. BROADBERRY (Tottenham) in introducing the report said: Mr. President, as the newly appointed Chairman of the Refractory Materials Committee, it is my privilege to present its report. In doing so, I feel somewhat at a disadvantage, because, although one of the original members of the Committee, it has been my misfortune for a period of two years not to have been a member; and the work is of so complex a nature as to make it difficult to pick up the dropped threads. For this reason, I want to emphasize the sense of loss and the sense of gratitude for important past services we feel in the retirement of Dr. Colman, who has so far conducted the affairs of the Committee with such great ability. On the other hand, I welcome, on behalf of the Committee, the prospect of the immediate return to his former activities in connection with these investigations of Major Bywater, who, up to the outbreak of the war, was as Secretary a powerful driving force of its work. No doubt he will soon regain his masterful grip of all that belongs to this research; and I look forward to his assuming the leadership at an early date in this subject, which has been one of his special studies. I feel that, in the national and industrial interest, I should merely act as a stop-gap. A considerable sum has been spent during the year by the Committee; and it is proposed during the coming year to double approximately the expenditure. The Institution, therefore, has the right to expect soon to obtain definite results. In my opinion, very decided results have already been obtained as a result of our labours, manifested in the improvement which has already taken place in the quality and durability in use of the materials concerned in the research. This is largely due to the willing co-operation of the fire-brick manufacturers, who have always shown a readiness not only to contribute towards the cost, but to adopt methods of manufacture indicated by the research as likely to improve the quality of their goods. The field of this research is so wide that it is difficult to see any finality; but so long as we constantly feel that the benefits are growing, we shall be encouraged to go on. The improvements which have so far resulted in longer life of retorts and settings cannot be assessed in exact figures of monetary value; but it is safe to say that the industry has benefited already very largely indeed from the energy, time, and cash that have been spent. The relation of grain size of grog to crushing strength of the material is one of the recent subjects investigated and dealt with in the report; and while grain size directly affects porosity, the new theory which is being investigated, that the insulating effect of porosity—*i.e.*, its resistance to conductivity—breaks down at high temperatures is of great value, and makes the report one of the highest interest. The inter-relationship of chemical and mechanical effects of different clays, aluminous and silicious, the firing contraction and after contraction on the one hand and the expansion when heated on the other, the texture and grog best suited to avoid cracking with abrupt changes of temperature and at the same time to produce the best conductivity where it is required, and avoid it where it is objectionable, the suitability of materials under load to resist fusion collapse and mechanical collapse, the corrosive and fluxing effects of various flue dusts, and many other problems are receiving, and will continue to receive, attention. It is greatly regretted that some degree of misfortune has fallen on the sample retort made by the slip process of casting, which is on exhibition to-day. Whatever care is taken in selecting materials, and whatever process is used in manufacture, there always remains the ordeal of firing or baking the otherwise finished body; and in this case our one sample has been hurried unduly for this meeting, and to some extent has come to grief in this final phase of manufacture. It is somewhat crazed, and one ugly fire crack, probably due to uneven firing, shows. On the whole, however, for a hurried first attempt it is not bad. Dr. Mellor continues his 24-hour day devotion to the work; and as he is here I will not take up more time. Mr. Leather, who has so ably performed the duties of Secretary, will also gladly supply any information required.

Mr. J. P. LEATHER (Burnley): I do not think I have very much to add to what Mr. Broadberry has said. I am sorry I have not been able to talk over matters with Dr. Mellor during the last week or two. I do not know exactly what his opinion is with regard to the retort which has been produced, and which is downstairs for exhibit. It was considered rather too heavy an article to bring on to the best part of the Institution's premises for fear of doing damage by its weight. There is nothing, perhaps, very much to see in the retort except the fact that it has been made by an entirely new process, which was referred to in last year's report. At the time when the question of producing retorts by what is known as the casting process was mentioned, it was thought that it would mean a very great expense. When it was put before the Committee first, we thought

that we were going to spend some thousands of pounds on the matter. But partly because the cost has not been so great as we thought, and partly because the manufacturers have so very readily helped in various ways—in fact, throughout the whole of the work of the Committee, as Mr. Broadberry has mentioned—it has not meant any very great cost. It has meant, nevertheless, a considerable amount of time. We shall be pleased to produce these retorts in fair quantities very soon, and then we hope they will be, as stated in the report, tried in practical use by members of the Association. With regard to the work done, I should like to add a few notes to what Mr. Broadberry has said, as to what the advantage of the work is. It is not possible for us to bring forward a number of figures and data which will be immediately understood by all the members, in such a way, for instance, as the report which was considered yesterday of the Gas Investigation Committee. Research into refractory materials is an exceedingly complicated matter of chemistry, and silicates is one of the most complicated branches of chemistry which requires going at rather slowly or rather cautiously if we are to bring forward actual practical results. There is this about the Refractory Materials Committee. It is one of the early Committees on Industrial Research. When we, as we have done in recent years, come into touch with the Committee on Scientific and Industrial Research of the Privy Council, we are congratulated on being one of the earliest industries to set about a definite scientific research on this important question of refractory materials. The effect of the work has been, at any rate, to improve one thing which I think the President referred to in his address—the alteration in the size of refractory materials for bricks and retorts in actual practice. It struck me very forcibly—of course, this is rather old history and is not in this year's report—when I took up the position of Secretary *pro tem.*, in consequence of Mr. Bywater's absence, that the Committee had already produced a very considerable effect, or at any rate something had; and it was coincident with the work of the Committee. Thousands and thousands of tests on fire-bricks have been made; and when we compare the tests on fire-bricks now on the market with those of two or three years previously, we see a very great change—a considerable alteration either in expansion of the silica materials or contraction of the fire-clay materials on exposure to heat. There is just one other point I should like to mention—I think Mr. Broadberry did not refer to it—and that is the process which we are also beginning to investigate. It was known as the Osmos process. It is not a very correct term; but it is the process which was boomed very much by, I think, the German owners of the patents just about the time the war started. The process is now being investigated, and will be further investigated very thoroughly; but whether or not it is really an advantage over the old processes time will show. When I was at Stoke recently I was much interested in a laboratory experiment that I witnessed for the electrolytic purification of fire-clay. It is a means, but whether an economical means or not remains to be proved, of obtaining a fire-clay having a far less proportion of iron in it than the raw material, and the process is much more quickly carried out than the old-fashioned washing-out process—simple direct treatment with water and washing out the impurities in that way. I think I may also refer to what is mentioned in the report, that we now have two full-time research workers under Dr. Mellor—viz., Mr. Emery and Dr. Bradshaw. The latter was in Germany in connection with the Osmos process at the outbreak of war, and, consequently, has gone through a considerable period of internment; but he has now come to work with us under Dr. Mellor's superintendence. I think in these workers we have two men who are very keen on their work, and who will do all that can be done to help us to ascertain the way in which a higher quality of refractory material can be obtained. Just one word more, and that is that the work of the Committee has, I think, had a very considerable effect on fire-brick manufacturers. It has been an incentive to them to form an Association of their own for further research on this work. First of all, I really think that it is to some extent due to our Committee that the Refractory Materials Section of the Ceramic Society was formed, and that the Research Association has been formed with the approval of the Committee of the Council of Scientific and Industrial Research, which I hope will carry on the work with increasing diligence and with increasingly good results.

A Smaller Sample.

The PRESIDENT remarked: I can assure you that the work of investigating into refractory materials is proceeding very thoroughly at Stoke, under Dr. Mellor, to whom, as I said yesterday, we, as an industry, owe a great debt of gratitude. I was very pleased to meet Dr. Bradshaw, who is the son of a townsman of ours. To show the need for investigation into these matters, I once saw the partial disintegration of a fire-brick, which, looked at from outside, revealed the truth of the fact that beauty, in a fire-brick, may be only skin deep, as it is said to be in some other instances. The brick was partly disintegrated by sand blast, and the grog or the mixture was found to consist of pebbles—pebbles of the right quality of material chemically, but, to show the physical condition, as soon as ever there had been any movement on that brick, upon heating in the structure to which it might have been put, each one of these pebbles, instead of serving the proper purpose of a grog in an article constructed of fire-clay material, would have proved more like roller-bearings on a piece of machinery that was constructed to move. The pebbles ought never to have been put in by any manufacturer. There was no excuse for it, if he had exercised any diligence in thinking of the effect that pebbles would have in a fire-brick constructed to stand heat. This was revealed by the skin of beauty being removed and nature being shown in all her nakedness, which was not beautiful. We have more hope of the work of this Committee. With regard to the exhibit downstairs, one of the rules of the Institution of Civil Engineers is that no exhibit shall exceed 2 cwt., and we received here an exhibit weighing some 7 cwt. However, we obtained permission to bring it in; and it is well worth seeing. I say that I am more satisfied with the work of the Committee, seeing that they have been brave enough to exhibit this piece of retort. Mr. Leather rather feared the expenditure of money; but the expenditure was exceeded because we were promised some models made by this process—pieces of models of retorts which members might try. There are so many different patterns of retorts in the industry, however, to our perplexity and to the perplexity and cost of everybody who has to make them, that I suggested that one standard pattern should be taken to show the result of this process. I suggest, however, that the sample is too big, and that it is absolutely unnecessary for the manufacturers who have made this, or for any other manufacturers, to make a piece of retort 16 in. by 5 ft. long, which means that it is necessarily almost twice the length of the gap in the combustion chamber of a retort-setting. The sample is sadly too long, and they need not have gone to such trouble and expense and risk in making a sample of a standard piece of retort. The retort itself would be better if it were supplied to the users in pieces half the length; then they would be entire. I think this would be better, inasmuch as it would mean several more joints to act as ribs in the structure as it moves either under the influence of heating or cooling. The piece of retort has two cracks, one each end. They are fire cracks, and show that the disintegrating effect of the heat to which the retort has been put in burning is far stronger than any power that is secured by the consistency of the material of which the body is formed. It suggests that, make them as you will, these pieces of tubular retort will be pulled all to pieces, and in all sorts of uncontrolled ways, when you heat them up for the first time in your settings, be the settings what they may. I think the whole thing suggests that the segmentary retort, the retort built up of segments, is the retort of the future, either for one form of retort or another. If it points to that, and that this process is not necessary to be proceeded with, proving too costly, the work of the Committee will have been infinitely useful and worth all the trouble and expense we have been put to in securing it, because of what it teaches us to avoid as well as what we have secured in knowledge in other directions. I can assure you the work of the Refractory Materials Committee is proceeding in a very helpful manner, and that work will continue to be done. Do you adopt the report as presented by Mr. Broadberry and seconded by Mr. Leather.

The report was unanimously adopted.

A Few Suggestions.

Dr. J. H. HARKER: I should like to make a few remarks if I may. I do think that it is desirable that one or two general things should be said about the work of this Com-

mittee which have not been said by anyone. I have just returned from America after a four months' visit for the Ministry of Munitions, and I think one thing I might say is that there is no name in the world in connection with refractory materials—especially in America—better known than Dr. Mellor's. During my visit to America, one of my objects was to get information for a Committee of the Conjoint Board of Scientific Societies, who are actively concerned in setting-up a laboratory where silicate chemistry can be studied, not only in its relations to geology and metrology, but to all the requirements of the refractory industry. I think I am not out of order in mentioning this. This is a most important development of the greatest possible moment to the Institution of Gas Engineers; and, when the right time comes and the report of this very influential Committee on which a large number of technical as well as scientific men are serving, goes to the Scientific and Industrial Research Department, it would be very fitting that the Institution should support by every means in its power the establishment of the laboratory which is contemplated. You are all familiar with the excellent work which has been done by the Carnegie Laboratory under the headship of Dr. Day, at Washington. The whole of the basic chemistry and physics of the properties of materials which is so vital to the refractory industry has been studied there perhaps more thoroughly than at any other place in the world. I felt it would be interesting to mention that first. Now I should like to say one or two words on the report itself. It is possible I have missed a meeting of the Refractory Committee, during the time I have been away, when this report was considered; but I do feel there is one thing which ought to be said. I think it would be very useful if Dr. Mellor, in preparing these reports for circulation to the industry, would remember that high and dry foliage and mathematical calculations without the results, which you expect to find given at the end of the paper, do not quite take us where we want to be on such a very important matter as the thermal conductivity of the materials which you are using in your industry. I feel that if the work on thermal conductivity of materials had been put before the Refractory Materials Committee on some earlier occasions, a number of the technical pitfalls into which I am afraid Dr. Mellor may have to some extent fallen in the method he has chosen, might have been avoided. I am very interested indeed in his theory about the reversal of the thermal conductivity of materials with certain sizes of pores at high temperature. It is a most important matter, and concerns all you people most vitally; but I do feel that it is rather premature to present a paper on heat conductivity and no results. I will not say more than this for the moment; but it is like presenting a *menu* for the table without anything to eat. I feel a little disappointed that it has been presented in this form. I do not want to criticize Dr. Mellor's work. I think he has been noble in the way he has worked in the most self-sacrificing manner ever since the Committee had his services, and I think that, instead of two new assistants, he ought to have had twenty. The Committee have been hammering away and doing things while other people have been talking; and this has been recognized to a considerable extent by the Research Department in the increased grant which we have obtained. I feel that these matters should not be lost sight of. It is of the utmost interest to the industry that they should not be allowed to take a back seat, and that there should be ventilation and discussion. There should be suggestions making more for publicity, and seeing a little more carefully to the presentation of our results in a form which would be most useful to those who want to use them. This is a very important matter. I have no objection to the papers which have been circulated; but they could have been made of much more interest to the public reading them than they are at present. It would be a desirable policy if, before things are brought at the last moment into public like this, they were submitted to the Committee for suggested improvements. I do not want to be at all hypercritical; I am simply asking that means should be taken to make these things easily understood. We do not want so much of integrals and differentials. In many respects, parts of the report are extremely interesting, and I looked to see how far the theories were borne out by practice. But the report has not even got the mathematics worked out. I do not want my remarks to be regarded as trenchant criticism of the work that has been done, but merely as an indication of matters of policy in which the work can be improved.

Mr. W. Newton Booth (Woolwich Arsenal Gas-Works): The importance of such work as is being carried out by the Refractory Materials Committee cannot, in my opinion, be easily over-estimated. When it is remembered that of a gas engineer's expenditure on plant some 30 p.ct. is on firebrick material, and that the most important of his operations, that of carbonization, is conducted in apparatus mainly composed of these materials, it will readily be seen what very great financial results may accrue from even a relatively small percentage improvement in the quality of the material used. Such improvement can only be brought about by the increased knowledge obtained from such researches; and it must be deeply gratifying to the members of the Institution to hear of the improved wearing and refractory properties, and the reduced shrinkage on firing, now being realized in refractory materials on the market. The Committee have reason to congratulate themselves on the results already obtained. The question of thermal conductivity, while, of course, subservient to refractory and wearing qualities, is also of very great importance. In different parts of an ordinary retort-setting, for instance, materials having absolutely opposite thermal properties are necessary. For example, in retorts and recuperators it is desired to pass the maximum amount of heat through the material with the minimum temperature head, demanding material of high thermal conductivity; while in containing walls it is desired to offer the maximum opposition to heat flow. So the material used should have as low a thermal conductivity as possible. It is therefore desirable to know under what conditions these desiderata can be obtained; and it is for this reason that I am very glad indeed to see that the Committee have undertaken the investigation of this subject, though I must confess that I share Dr. Harker's disappointment at the very incomplete nature of the information so far given. In connection with the design of a new type of gas-furnace on which I have been engaged, and which is giving most promising results, although it is yet only in the experimental stage (economies of 60 p.ct. in gas consumption and an increase of over 300° C. in working temperature attained as compared with the common types of furnace in use having already been obtained), I have found it necessary to get exact ideas as to the thermal properties of the materials used, and as to the variation of these properties with temperature; and I think that the preliminary results already obtained should prove of interest, and perhaps of assistance, to the scientific advisers of the Committee. As, however, Dr. Harker has said that integrals and differentials are of no immediate interest to the Institution, and as my further remarks would involve the use of such functions, I would like, with your permission, to submit them in the form of a written statement for insertion in the proceedings.

At the close of the meeting, the following written statement was handed in by Mr. Booth: When first attacking the problem of the design of this furnace, I was struck by the lack of information as to the thermal properties of common refractory materials, and especially as to the manner in which these properties are affected by the working temperature, and by variations in the structure and method of manufacture of the material. Such results as had been published were hardly consistent with each other, and the several equations which had been proposed for interpreting the results were obviously purely empirical. It seemed to me that there must be an adequate explanation for the observed facts; and in attempting to formulate such an explanation, I was led into the following argument. The thermal conductivity of a substance, as defined by the usual equation $k = \delta Q \frac{dx}{d\theta}$, may, and probably is, the sum of a number of independent factors according to the precise manner in which the heat is transmitted through the substance. In the case of gases, an adequate explanation of the observed conductivity is given by the kinetic theory; and it seemed to me that this problem might yield to a similar attack. It appeared to me that the mechanism of conduction would be of three types:

1.—That in which the heat is actually transmitted by intermolecular action—*i.e.*, by the actual transference of kinetic energy between contiguous molecules. This would be the chief method in the case of a non-porous material which was a poor conductor of electricity.

2.—That in which the heat is conducted by mechanism similar to that concerned in the conduction of elec-

tricity. This would be the chief method in the case of metals and other good electrical conductors.

3.—That in which the heat is transmitted across the pores of the body by radiation or by convection and conduction in the medium filling the pores.

In order to obtain an equation which can be submitted to the test of experiment, it is necessary to make certain assumptions; and the following appeared to me the most reasonable: As regards No. 1, the rate at which energy can be transmitted between contiguous molecules should be proportional to the following factors: (*a*) The "force" that is exerted between contiguous molecules. This accounts for, and can be calculated from, the internal pressure of the solid. In those cases where this "pressure" has been measured, it is found to be representable by a function of the form $a(1-b\theta)$; (*b*) the difference in energy between contiguous molecules which is clearly $K\gamma \frac{d\theta}{dx}$ where K is the diffusivity of the material; (*c*) the number of collisions between molecules, which number is proportional to the square root of the absolute temperature if we neglect the relatively small alteration in the dimensions of the material due to thermal expansion.

As regards No. 2, the relation between thermal and electrical conductivity was investigated by Sir J. J. Thomson in connection with his development of the corpuscular theory of matter; and the relation he arrived at is represented by the equation

$$\frac{k}{c} = \frac{4}{3}\frac{a^2\theta}{e^2} \quad *$$

* Thomson's "Corpuscular Theory of Matter," p. 56.

As regards No. 3, the theory of this is very ably dealt with in the report. I should like to remark, however, that it seems to me that the undoubted roughness of the inner surfaces of the pores will have the effect of largely increasing the effective area of the radiation when it is remembered that the amount of heat transmitted is independent of the distance across the pore, and is a function only of the radiating area and the difference in the fourth powers of the absolute temperatures of opposite surfaces. Such considerations have led me to a formula of the following form for expressing the probable variation of thermal conductivity with temperature; the constants being functions only of the material concerned:

$$k_\theta = A(\theta^{\frac{1}{2}} - b\theta^{\frac{3}{2}}) + B\frac{c_\theta\theta}{273} + D\theta^3$$

where C_θ is the electrical conductivity at absolute temperature θ.

The following table, adapted from information given in Prof. Stansfield's book on "The Electric Furnace," shows the variation with temperature of the electrical conductivity of common refractory materials.

It will be seen that at temperatures below 1200° C. the electrical conductivities are relatively small, and may be neglected in most calculations of thermal conductivity. But as the temperature increases, the relative importance of this factor becomes greater; and it may in some cases be necessary to take it into account. Neglecting electrical conductivity, the equation given above reduces to:

$$k_\theta = A\theta^{\frac{1}{2}} - B\theta^{\frac{3}{2}} + D\theta^3$$

Temperature °C.	Electrical Conductivity in Reciprocal Ohms per Cub. Cm.			
	Firebrick.	Silica Brick.	Magnesite Brick.	Chrome Brick.
600	0·000048	..	..	..
700	0·000059	..	..	..
800	0·000077	..	..	0·000357
900	0·000111	..	..	0·00132
1000	0·000166	..	..	0·00238
1100	0·000228	..	..	0·00233
1200	0·000435	..	..	0·00222
1300	0·000770	0·000103	0·000161	0·00244
1400	0·00145	0·000416	0·00238	0·00312
1500	0·00357	0·00141	0·0182	0·
1550	0·01667	0·0455	0·0333	0·
1565		0·0555	0·040	

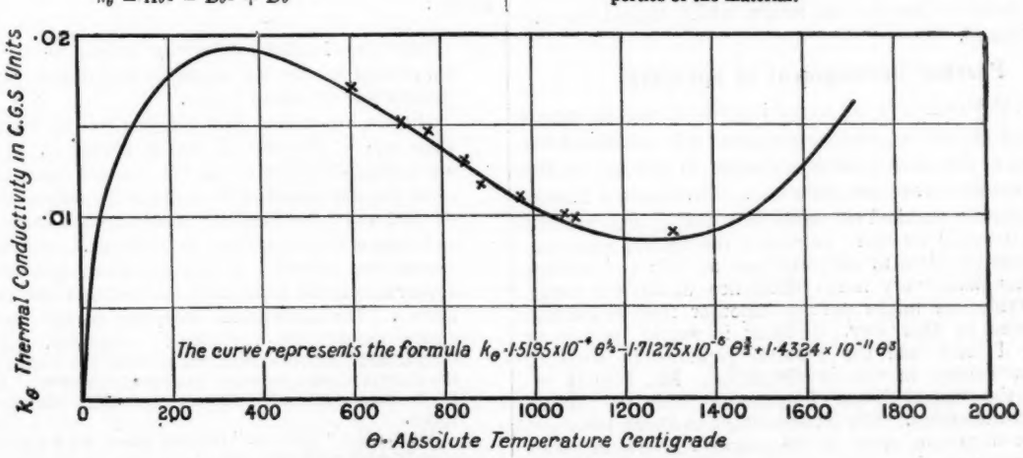
Owing to the change of crystalline state, which occurs at certain temperatures in silicate materials, these would not be the best materials with which to commence an investigation into the validity of such a formula. I have consequently been compelled to look into the properties of more simple substances. These investigations are as yet very incomplete, and progress with the limited resources for exact experimental work usually found in a gas-works laboratory is necessarily slow. If the Committee consider the matter of sufficient interest for them to take up work upon the subject, better progress will undoubtedly be possible; and the results obtained may lead to important practical improvements in the thermal qualities of available materials in the same manner as has already applied in the case of other qualities.

The question of the physical interpretation of the constants in such a formula as I have proposed is receiving my attention; and I am hoping to arrive at a clearer idea of the factors involved in the conduction of heat through refractories, and as to how this may be effected in any way we may desire. Such work is necessarily hampered by the small amount of experimental information at present available; and this the Committee are now setting themselves to rectify. At the present time I have no experimental results ready for publication. But as an illustration that the form of the formula does represent fairly accurately the behaviour of such comparatively simple material as a magnesia brick, I have taken the liberty of preparing the attached graph showing the application of the formula to the results that were obtained at Leeds University by Messrs. Dougill, Housmann, and Cobb in the case of a magnesia brick. [See "Journal Soc. Chem. Industry," May 15, 1915.] I trust that these gentlemen will forgive me for suggesting that the curve obtained expresses their results at least as well as that suggested by them.

In the above remarks the various symbols used have the following significance:

- θ Absolute temperature centigrade.
- k Thermal conductivity at temperature θ.
- Q Quantity of heat.
- x Linear dimension along line of heat flow.
- K Diffusivity of material.
- γ Molecular dimensions of material.
- c Electrical conductivity.
- α Increase in kinetic energy of a molecule per °C.
- ϵ Electrical charge on an electron.

A, B, D, *a*, *b*, are constants determined by the physical properties of the material.



THERMAL CONDUCTIVITY OF MAGNESIA BRICK.

Dougill, Housmann, and Cobb's Results.

The Work of the Ceramic Society.

Sir WILLIAM JONES: I had no idea that I should be privileged to speak; but, as the President of the Ceramic Society and as the ex-Chairman of the Refractory Materials Section of it, I should like to say, on their behalf, how much they recognize the valuable work which has been inaugurated in a large measure by the Institution of Gas Engineers in regard to research into the qualities of refractory materials. The Society to which I have alluded is composed for the most part of manufacturers; and it has been thought that it would be a fitting medium for developing on a somewhat larger scale this question of refractory research, because, while it recognizes that the work which appertains particularly to the gas industry is of the highest importance, the Society—composed as it is for the most part of manufacturers of refractories—feels that the work, of course, is not confined to the gas industry, but concerns other staple industries of the country, such, for instance, as the great steel industry, and the non-ferrous and chemical industries—indeed, all the industries which are dependent upon heat radiation processes are interested in this great subject of refractories. Therefore the Ceramic Society has taken the initiative in putting forward a somewhat comprehensive scheme which I think probably would meet the desires of our friend, Dr. Harker. We have been in conference with the Privy Council Committee for Scientific and Industrial Research; and the whole project has crystallized. We have submitted our plans to them, and I am glad to say they have met with their full approval. Dr. Mellor has undertaken to act as Technical Director of the new Refractories Research Association which has been projected; and I am glad to say that the steel industries of the country have looked upon the project with favour. Dr. Mellor calculates that the expenditure required to carry out this comprehensive scheme will be somewhere in the neighbourhood of £6000 per annum for the next five years, of which half will be provided by the Privy Council Committee, and I am glad to say there is every prospect of raising £3000 per annum for the next five years. I do not propose to detain the meeting by entering into further details. Suffice it to say that a Committee has been formed, for the most part of responsible and practical manufacturers, aided also by well-known scientists who are interested in the subject; and we are going forward now with this large scheme. It is one which I have very much at heart; and I am quite sure that we can depend upon the co-operation and support of the Institution of Gas Engineers.

The PRESIDENT: I move, with the explanation that the report is a preliminary one and that more is promised, that the report as submitted be adopted.

Mr. C. F. BOTLEY (Hastings): I beg to second that.

The report was adopted.

Report of the Life of Gas-Meters Joint Committee.

[See p. 622.]

Mr. J. G. TAPLAY introduced the report.

The PRESIDENT: I am sure you will agree with me that it is a very concise report, containing hints and anticipations of promises also for the future, which should be very helpful indeed.

Further Development of Spraying.

Mr. B. R. PARKINSON: I would just like to say, in regard to the first table of aqueous vapour, that it is calculated out according to the exact quantity of water in the gas at the various temperatures and pressures. Mr. Stephen Lacey, who has kindly checked the table over for us, has pointed out that it would be more helpful if the figures were corrected so as to relate to saturated gas at 60°; and though it does not make very much difference within the range of the table, we might perhaps another time re-publish it corrected in this way. I think it would be fair to say that I have had the greatest pleasure in working with Mr. Taplay in this investigation. Mr. Taplay represents the "goods," and I represent only the brown paper and the string. We have written to about forty gas engineers in various parts of the country, of whom about twenty have replied. It is not everyone who can answer off-hand questions such as we have asked amid other duties. Some have taken a great deal of trouble. We sent fourteen questions, and we also asked for samples of condensates and of deposits; and Mr. Taplay has actually analyzed a great number of these—viz., twenty-two deposits, three purifier oxides, nine samples of condensed water, and six samples of condensed oil. In sending round the questions, my idea was that we might be able to tabulate information and get results from them. We have to some extent; but by far the most valuable results have been obtained from clues struck in unexpected places. By sending broadcast for information, speaking on the subject in season and out of season, and thus following-up every possible avenue, one is bound in time to find out the person who knows the secret of what you are looking for. My idea is that, in an investigation of this sort, within an industry like this, there is someone who knows—probably considerably more than one person who knows; and if you persist, you can find that person eventually, and get the information. During the preliminary investigation which resulted in the spraying of meters, it was found that Glasgow and Leeds were already trying some process of this kind; and our conclusions were thus strengthened. Since then, meter spraying has been taken up all over the country, and where the method has been used with discretion, it has I believe been of value and economy. Now, the conclusions arrived at have to do with the oil-spraying of mains; and this, again, has been confirmed in a striking manner by the correspondence. As an example, I would like to read letters which have passed between myself and Mr. H. R. Wimhurst, of Bury St. Edmunds, since the report was printed. This is by far the most valuable correspondence we have had, because it proves that, over a number of years in practice, the theoretical conclusion which Mr. Taplay has come to has been confirmed. My letter to Mr. Wimhurst was as follows:

May 20, 1919.

Dear Sir,—I am writing to you in reference to your address before the Eastern Counties Gas Managers' Association. There is a paragraph on p. 295 of the "Gas Journal," May 6, headed "Naphthalene Stoppages," which is of great interest to Mr. Taplay and myself. We are investigating for the Institution of Gas Engineers the subject of internal corrosion of mains and services. This matter is a sequel to the papers which were read before the Institution last October. It was then recommended that spraying with paraffin oil was a remedy for some of the troubles with gas-meters, arising out of present-day gas. Apparently you have anticipated this prescription, and had already been spraying petroleum into your mains for the same purpose. I drew Mr. Taplay's attention to your address; and he thought that your plant for atomizing the oil was similar to the Botley plant, but probably very much smaller and simpler. Mr. Taplay is strongly in favour of putting in the oil vapour cold, because otherwise such a large proportion of oil that is put in hot comes down immediately. We are recommending a film of oil for the interior of mains and services, as well as meters, in a report presented to the Institution at the meeting next week. It occurred to us that you might perhaps have some comments to make on the matter, which would be useful to us in this investigation.

Mr. Wimhurst's reply to my letter was in the following terms:

May 23, 1919.

Dear Sir,—I thank you for your letter of the 20th inst., and am pleased to hear that my recent reference to spraying with paraffin was of interest to you.

My first experiment with spraying was made eight or ten years ago, at the works I was in charge of. Our trouble was naphthalene, both on the works and in the district. The spray was introduced at the outlet of the station meter. The oil used was a tar distillate something like crude naphtha, and known by the makers as "Solvene." This oil quickly cleared our gasholder connections, and began to make its appearance in the mains and services, and also consumers' meters. The naphthalene stoppages in the district were greatly reduced, but not entirely eliminated. No doubt if the gas had been sprayed at the outlet of the station governor, the district stoppages would have ceased entirely. Obviously the holders would act as a sort of settling chamber for the spray.

After using "Solvene" for two years, we began to experience trouble with the meters. Upon examination we found the oil was having a bad effect on the leathers. Really this was not to be wondered at, as the oil was a very crude pro-

duct, which could not fail to have a deleterious action on leather. We next tried ordinary paraffin oil, and found it quite effective as a naphthalene solvent, and our meter troubles became less frequent.

The apparatus used for spraying was an ordinary spray nozzle such as is used for spraying fruit trees. This was supplied with oil at 25 lbs. per square inch. The oil was pumped by a very small steam-pump drawing from a sump tank placed beneath the gas-main. The main was drained into this sump tank, and any surplus of oil not carried forward by the gas stream was conducted back into the tank and circulated over again. The whole apparatus was very simple and inexpensive, both in installation and operation.

My next attempt at oil-spraying commenced at these works about two years ago. I decided this time to follow the Botley method—that is, to atomize the oil with gas under pressure. I had some difficulty in selecting a suitable type of compressor. Eventually, I fixed on the Westinghouse as being simple and cheap. The whole outfit cost us about £60, including the oil-tank and gas-storage cylinder, gauges, &c. No alterations were necessary to the gas-mains. We just drilled a 1¼ in. hole in the trunk main as it leaves the works, and screwed the spray nozzle into it.

I am not a believer in vapourizing the oil. My view is that the oil should be in mechanical suspension in the gas. In this state it carries further, and will be deposited where the gas is subjected to changes in velocity or direction. These changes occur in the meters and in naphthalene obstructed pipes, and the oil comes down and carries on its beneficent operations. The spraying process should do much to prevent the interior corrosion of mains and services by "greasing" the interior surfaces of the same.

We have observed that our mains are gradually becoming "greased" internally, and that the deposit of corrosion lying at the bottom of the mains is being impregnated with oil.

(Signed) H. R. WIMHURST.

Why not Spray in the Mains?

Mr. C. F. BOTLEY (Hastings): Perhaps not unnaturally, after twenty years' use of the process with which I am identified, it is very interesting to have the present generation expressing their views upon what, if I may say so without presumption, has been rather apparent to me for many years. Perhaps I might take the opportunity—I do not think I have mentioned it publicly before—of saying that one of the reasons why I did not proceed with the experiments with regard to naphthalene without any cold distillate was primarily the fact that I should expect the unfortunate results that we get. One meter-maker at the time was good enough to look into the matter with me; and he expressed the view that refined petroleum, far from being any detriment at all, would be very advantageous to the diaphragms of the meters. I believe I supplied Mr. Taplay with some information, although unfortunately, among so many statistics kept in this matter, I do not think we got actual figures which would have been useful to Mr. Taplay to compare with other places. But so far as I am any judge, and as far as I have any information at all, I believe that our record in regard to meters, as one would naturally expect, has been a particularly good one. Of course, as regards naphthalene or corrosion in the mains, we have not had any trouble at all during the war or for many years past. It is perhaps unnecessary to emphasize this, inasmuch as the carburation process is now known all over the world; and I think if it is used as it is designed it must be effectual. Apart from anything else, imitation is the sincerest form of flattery. When one finds that directly or indirectly the method is being pursued, it is obvious that it is very successful; but when one sees some of one's friends spraying meters individually, one is forced to the conclusion that it seems rather an unnecessary process. If you must spray the meters first of all, you must be doing the same on your mains as well sooner as later. Consequently, if it has to be done, why not do it at once on the outlet of the governors and save the trouble and, in future, the expense. But though these other methods which have been founded on the Hastings process are satisfactory, they are inefficient as compared with the process as designed. Even if you achieve certain results, you cannot stick the sprayer into a gas-main—I do not care what sprayer it is—and work it blindly without pressure, compared with having a proper carburettor wherein you can see what is going on at all times, and atomize the oil supplied to the best possible advantage. You must necessarily use a greater amount of oil; and although a certain proportion of the atomized oil goes forward, the process must necessarily be slower. I do not know whether the engineer concerned is in the room; but I have had an opportunity of putting the process to work in a novel way on some very large trunk mains. It was impracticable in mains of this size to insert the carburettor in such a manner as to see what was going on. The only way to do it was to insert the atomizers in the mains—the latter being large enough so that the atomizers could expand; the principle being that atomized oil remains suspended as a mist, and comes down with anything solid. Therefore, with atomized oil you must have sufficient room, so that it can expand into the gas before the mist is likely to become predominant. What is found in these big mains is that a very large proportion of the oil comes down very quickly. I think I may safely say, from my experience, that it is not as much as it is thought to be in this particular case. But there is a very large proportion; and there is also the action which goes on to which my friend Mr. Leather called attention many years ago. There is a certain amount of deposition and of transposition—something is given up and something is taken up; and this certainly has the effect of making the gas in that condition which prevents corrosion and also prevents naphthalene. If this trouble is growing—and one cannot help feeling that it is growing, and particularly when you are distributing gas, not poor gas, but gas of economic quality containing rather more oxygen than usual—you have got the best possible conditions for corrosion in mains; and where the oil process is not in use, trouble must be expected. I might also mention just one experience on a works, where this oil process is not in use, where the trouble has been very acute during the war, and where revivification of the purifiers was carried on perhaps not on highly scientific lines, with the result that the increased amount of air corroded practically everything, not only the meters, but the services as well, and many of them had to be taken down. This is, I think, conclusive evidence that the presence of an excess of air or oxygen in the distribution of gas, especially with hydrocyanic acid, must be detrimental, and can only be obviated, assuming the gas is properly made and distributed, by some oil solvent to reinstate the gas into the condition that it used to be in the good old days when we had flat-flame burners and semi-permanent gas.

Experiences at Liverpool.

Mr. R. E. GIBSON (Liverpool): There are just two points that I might mention. Many years ago we tried Solvene as a treatment for naphthalene; and while we were quite satisfied that it conducted the naphthalene out, the complaints on the district in question continued to increase. We therefore came to the conclusion that when the Solvene became saturated with naphthalene it brought down the naphthalene in the mains and services. I am not sure whether this is the corect explanation of what took place.

The PRESIDENT: You mean the Solvene got saturated with naphthalene and deposited it a little further on.

Mr. GIBSON: Yes, that is the conclusion we came to. But we have been for some time now spraying the mains with paraffin, with excellent results. The number of stoppages has decreased considerably, and at the present time the amount is practically nothing at all. In answer to Mr. Botley, who mentioned that the disadvantage of the spraying system was that one could not see what was going into the mains and whether anything was going in or not, we have fitted sight-feeds to our pipes leading to the sprays, and can see all the time the amount of oil entering.

Mr. BOTLEY: Do not let me be accused of making myself misunderstood. What I said, or what I wished to say, was this: It is not a question of the amount of oil that is put into the mains; it is a question of whether it is properly atomized when it gets into them. It is easy enough to know how much oil you are putting in; but the question is whether you are atomizing it. Just spraying a solid jet of oil into a main is nothing at all; it must be atomized.

The PRESIDENT: I am sorry Mr. Wimhurst is not here. I think both Mr. Botley and Mr. Gibson understand the point with regard to the oil. You know the amount of oil that is entering; but you want to be able to see whether the effect of the pressure is atomizing the oil. Mr. Gibson is now finding the atomized oil further and further afield in his distribution system. We are now talking of atomizing

mechanically; but, notwithstanding what Mr. Taplay has said, I cannot yet—and I am going to submit this to you for your further consideration—understand how you can mechanically atomize oil as beautifully (speaking of it as atoms) as you can by proper vaporization, nor can I understand how atomized oil, which has its temperature temporarily raised in the process, when it is mixed with the proper stream of gas, can possibly condense out again so quickly as is feared by Mr. Taplay. I am very glad to hear from different parts of the country that gas engineers have persevered with the atomization of oil of the right sort, which is a very important matter. In the report, Mr. Taplay speaks of the prevention of naphthalene; but I do wish he would be a bit more discreet in speaking of the effect upon naphthalene, which you do not prevent being formed by the application outside your works of some carrier, or whatever you may use. The effect upon naphthalene deposits, yes, I can understand that. But the naphthalene has, of course, in the first place to be there; and many engineers have had to learn, who were very slow to learn, that you have to be very persevering with this cure for naphthalene stoppages. It is not a matter of a few days spraying the gas that goes into the mains, but you want to bring about the position which has been graphically described, that your main interiors are being coated with a film of oil until the evidence of the oil is proved in your syphon pots, your services, and your meters. The process has been applied in cases where naphthalene deposits have been troublesome, until it was found to be coming out of the tips of the burners, so that the consumers' fittings were being lubricated inside. Therefore you must consider the best means of atomizing your oil and spraying it into the stream of gas so that it is carried along with the stream until every nook and corner of your whole distributing system is found affected by the atomized oil, and also that the paraffin oil so used has some effect, when it gets to the flame, upon the illuminating and heat-giving qualities of the flame. I think you will agree with me that this subject is being carefully considered, and that it is of the utmost value to the whole of the profession. At the same time I do feel that it is quite time we understood that the bogey of naphthalene troubles and distribution troubles has been laid, and that, as the result of study and improvements, it has been mastered. It can be mastered; and those who have not mastered it can do so, and in this way can add to the service they have to render to the people they have to serve.

A Meter Maker's Views.

Mr. Thomas Glover (Messrs. Thomas Glover & Co.): I really had no idea that you were going to ask me to offer any remarks. I have nothing prepared, and probably Mr. Cockey, as the Chairman of the Meter Section of the Society of British Gas Industries, has some facts to put before the meeting. I have been exceedingly interested in listening to the discussion; and there are one or two points which occur to me to which I should like to draw attention. I take a peculiar interest in this report of the Committee, because when the inquiry started some years ago I think I had a great deal to do with it, and, admittedly, it was taken up from the point of view solely of the meter maker, who was trying to study the best ways and means of improving the piece of apparatus with which he was more particularly associated. Therefore, it does seem to me interesting to find that the investigations of the Committee are not only covering questions relating to meters, but are now getting practically through the whole of the distributing system. I venture to think that some of the work of the Committee will be of great interest and of great service to the whole industry, to the makers of other classes of apparatus, and to gas distribution generally. In regard to the question of spraying meters, I am expressing only a personal opinion; but it has been my experience that when meters are used in districts in which we will say naphthalene solvents, such as Solvene, are introduced indiscriminately, whatever the effect may have been on the removal of the naphthalene deposits in the services, the results to the meters and other pieces of apparatus have been very disastrous. I think the key to the whole thing is this: You must introduce into the gas—I think it was Mr. Botley who spoke of poor gas, and I do not know whether he meant poor gas or war gas, I should prefer to call it war gas—as I understand it, some carrier which will take right through your services and meters, and also your burners, these compounds that are doing so much harm at the present time. Whether you vaporize your oil or whether you atomize it, I think it is possible to introduce sufficient of a heavy oil. The secret there is that it must be a refined oil, as I think the President said.

The President: I said an oil of proper quality and of the right vapour tension. You use the vague words "heavy oil;" and I wish you would use the words which are much more indicative of the sort of oil that is required.

Mr. T. Glover: I am speaking of oils which are at least heavier than the common lighting oil, which are known as paraffin, provided it is a pure oil. There is only one word of warning I should like to suggest, if I may; and it is this. I think the solution for your present troubles lies in the use of oil; but possibly you may find that with the use of other agents, such as Solvene, a point will be reached when you have got through the whole of your service mains and apparatus, and when you will find it will not be wise to continue to use oil to the same extent as you find it necessary now when you have an accumulation of deposits to deal with. I think this should have some attention given to it. In regard to spraying meters before they are fixed, if I may be allowed to express a personal opinion, it would be that the meters, as received into your works, are better not touched until they have been fixed on the services. Then I agree with previous speakers that the spraying can do nothing but good, providing you are using oil of the right nature; but I would suggest that it is not advisable to spray meters indiscriminately before they are fixed on the services.

Dr. W. B. Davidson: I should like to say a few words on the question of dust and deposits. During the last few years I have had the unfortunate experience of having to deal with gases which carry dust, or rather having to deal with very fine dust which must be carried in a gas of the right specific gravity and suitable velocity; and I would like to suggest to the Committee who are investigating this subject of corrosion of meters that it is possible, in certain circumstances, for the fine and artificially dried oxide to be carried right from the last purifier through the meter, through the holder, and into the services. I have had to deal with pyrites containing a large proportion of very fine dust, one-third of which has gone through a 90-mesh sieve. When this stuff is burned, the burnt ore is still finer. We have a dust chamber which throws down about 90 p.ct. of the dust; and I should say that the 10 p.ct. which leaves the burner is carried beyond the dust-chamber, through two wet tower scrubbers, three coke-filters in series, two wet drying towers, a suction chamber, an exhauster, a pressure chamber, and another scrubber right through to the contact chamber, and there contaminates and poisons the platinum. The velocity of the gas there is about 8 or 10 ft. per second. This is not the only trouble. We have also found dust on the platinum mass, and the platinum dust and dry Epsom salts, which are subject to the high temperature of the gases, go through at a higher velocity still, and also reach the contact chamber. The rate of the gas is then about 20 ft. per second. This dust is carried forward, and a good deal of it is lost; and it is a very serious loss. My experience rather gives me the idea that it is possible, especially in these times when the specific gravity of gas is much higher, and you know the reason. [Laughter.]

The President: Some gases, if you please.

Dr. Davidson: And the volume is naturally much greater, because you have to supply the same number of B.Th.U. Then these conditions favour the carrying forward of the oxide. I did hear—and this is proof of my contention—that the dust collected from the syphon boxes on the district, and especially on high-pressure mains, varies in grading—*i.e.*, the dust collected near the works was of a larger size, while that further from the works was very fine. I think there is a possibility of this happening. The President took the words out of my mouth about the spraying. I wished to say, because I have had a good deal of experience with mist—and that is another great trouble—that the way to get the finest mist is to get the vapour rising, because when you get slow condensation naturally the globules would be in a finer state of division, and there is no absolutely perfect mechanical apparatus that will give you the smallest drop.

The President: Mr. Taplay will reply to some of the questions, and deal later on with the remainder.

Mr. TAPLAY: In reply to Mr. Botley, I was speaking about spraying meters rather than atomizing oil into the mains. I do not think we want to do away altogether with the spraying of the mains by means of vaporizers of some description. What we were doing in spraying meters was brought about by the fact that they could not wait in certain districts while the oil from the vaporizers arrived at that point. It takes a good long time. On one of our districts the plant has been in use for 14 years, and we find that the whole of the district is well saturated now with paraffin; but you could not do that during two or three years of the war when gas was poor, and we could not wait. So the meters themselves had not to be sprayed. As to Mr. Gibson's point about Solvene. This is volatile, and having dissolved the naphthalene, if such a thing is volatile, it will leave the naphthalene in the main. It is not like paraffin oil, which has a low vapour tension and a fairly high boiling point. There, if the naphthalene goes down, the paraffin goes down first. With regard to the President's remarks about producing vapour by means of heat, or by emanation, I should like to draw attention to the fact that it is not a question of an argument for or against either method that we are investigating at the present time. We say that these things are based on the experience in one of our districts of the Gas Light and Coke Company, where we put in paraffin oil vapour cold into the main—*i.e.*, after atomizing it. We use on the average 3 gallons per million, and nothing comes back; whereas in another district, where it is vaporized by steam heat, we employ on the average 15 gallons per million, and anything up to 8 gallons are returned. In regard to Mr. Thomas Glover's remarks as to the oil which is required, which should have a low vapour tension, that is the kind of oil which is required to be put into mains, services, and meters, so that it does not evaporate very quickly. That is why I chose Solar oil. I may say that in this particular district, where we are using cold atomizing plant, there is only about 1½ p.ct. of the meters which go wrong, because of the paraffin being distributed so successfully. It has been going on for the past fourteen years; and I think we can say that 1½ p.ct. of meters going wrong is not a very bad record. With regard to Dr. Davidson's remarks concerning dust deposits, I quite agree that there are cases in which such deposits may travel very long distances; but surely if the deposits which are found in the services and meters had come from the purifiers, would it not be certain that some would be found in the station meters, for instance? We have investigated these deposits; and we do find them in the station meters. Moreover, in the deposits alluded to from the services, the sulphur is very much lower than if they came from the purifiers. I have many cases here. The sulphur is from 1·3 to 0·05 p.ct., whereas if they came from the purifiers we should have up to 50 or 60 p.ct., probably. Again, none of these deposits have been found to contain peat or sawdust. It is true that they do contain free carbon; but that most certainly comes from the bitumastic covering used for the internal coating of the pipe. They contain no hydrogen, which would be necessary if they were peat or sawdust.

The PRESIDENT: I do not know why you call it bitumastic covering. It is very often common coal tar pitch containing carbon.

Mr. TAPLAY: Quite so; but that is the name which was given to me by the people who were selling it.

The PRESIDENT: It is a misnomer.

Dr. DAVIDSON: The catch boxes usually contain very little sulphur.

Mr. TAPLAY: That may be. Figures that I have here for catch boxes are 5 p.ct. and 4·5 p.ct.; but the amount of sulphur in the deposits is in the neighbourhood of 0·1 and 0·2 p.ct. Then there is the blue or ferric ferrocyanide in the deposits. In the oxide it is of the order of 21 p.ct.—19, 16, and 20 p.ct. are figures that I have; but you do not get that in the blue. The highest I have is 3½ p.ct.

Dr. DAVIDSON: Is not that likely to be a mixture? There are several contributory causes; and I do not think you can apply any particular one.

Mr. TAPLAY: Perhaps not. I certainly think that the main trouble does not come from the purifiers. I am not disputing that a little may; but the chief trouble does not come from the purifiers. If this were so, how is it that we are free from deposits in the mains and services of the Gas Light and Coke Company? The high-pressure mains are free from deposits; we do not get corrosion. A piece of 8-in. high-pressure main, 23 ft. long, taken out a few days ago, had not the slightest trace of deposit except what you could rub it off with the finger. We have oxygen, carbon, benzol, moisture, and everything but the hydrocyanic acid in the gas, and we do not get it.

The PRESIDENT: Recognizing the work of the Committee and the associated manufacturers on this subject, I think you are now prepared to accept the report in the meantime, and ask the Committee to go on and do more. I propose the adoption of the report.

The report was unanimously agreed to.

A Message from Mr. Thomas Duxbury.

At the opening of the proceedings on Thursday morning,

The PRESIDENT said: I have to communicate a message from our old and esteemed member, Mr. Thomas Duxbury. This is the message through his brother:—

> Dear President,—My brother sends greetings to the President and members of the Institution and very much regrets his inability to be present at the Conference, as this is the first meeting he has been absent from since he joined the Institution. He is at present at Southport and is improving in health, although slowly.
>
> (Signed) TIM DUXBURY.

Is it your wish, gentlemen, that a message be sent to Mr. Duxbury thanking him, and expressing the hope that he will soon be restored to perfect health and strength?

The members agreed.

A Benevolent Fund Appeal.

The PRESIDENT: I have now a duty to perform, in accordance with a promise I made at the meeting of the Benevolent Fund Committee. I feel that so many of our members are deeply in sympathy with the aims and objects of the work that is performed by the Benevolent Fund, that I do not need to say anything much. But they desire me to say something in support of the fund, and to gather, if possible, more liberal funds, because the recipients of the benefices from the fund are, of course, finding that the money that we are able to give is not of the purchasing value that it used to be. In particular I want this to go out to each member of the Institution; and I do hope that you will bear with me while we, who are most of us subscribers, send it to the other members, and take it to our own hearts, if we can in any way increase our subscriptions so that the funds and the subscriptions and the donations that we get in will realize the necessary amount to do a greater measure of work through the fund. If anyone can find it in his heart to give us what he is able to gather together in any way for the benefit of those who have fallen on days of affliction, or for the benefit of the widows and orphans and those who have no helpers, it will be devoting—I use the term in the highest possible sense—some of their means, and the result of the successful work earned by the health and strength that God has given them, to helping the more helpless ones who are needing our help. I feel quite sure that this appeal will not be made in vain.

Other Business.

I would have liked to have had an opportunity of giving occasion for "Other Business," as there often is in our meetings, and, if we had the opportunity, to spend some little time on any subject that may have come along. Some have made suggestions in letters; and we will try to deal with these suggestions as soon as possible through the Council, who are going to have a meeting this afternoon. Mr. Auchterlonie has written to us, for instance, on the matter of the adjustment of working hours, and also on the question of gas-stove and meter rents. On the other hand, there are some few questions that could be answered at the meeting if we had time, other than those that will be dealt with at the special meeting this afternoon. If there is not time to answer them before we close, occasion will be taken to do so through the medium of the Press, as part of the "Transactions." With reference to receiving communications, I think we had better reiterate the invitation to those who want to communicate on any subject that is discussed

—and perhaps only partially discussed as they may feel—to do so. On the subject of education yesterday, for example, there are several very interesting communications that might be received. For instance, we had with us the son of our member and old friend, Mr. Irminger, of Copenhagen; and he would have said something, if he had felt that he could do so in good enough English for the ears of British gas engineers. He refrained from doing so; but I think he could send a very useful communication, if you would allow him to do so. My son, too (being the son of his father), would have liked to have said a few words; and I think, perhaps, you would encourage him to send a message from his point of view, as to the proper training of gas engineers. I have now great pleasure in inviting my friend Dr. Davidson to respond to my invitation to give us a lecture on the inter-relation of the gas and the dye industries—a subject to which he is devoting his time at the present moment.

THE INTER-RELATION OF THE GAS AND DYE INDUSTRIES.

By W. B. DAVIDSON, D.Sc., of Huddersfield.

Dr. Davidson then gave an abstract of the following paper, which he accompanied by a few experiments and a most excellent array of samples provided by British Dyes, Ltd. He expressed his thanks to Mr. Turner, the Managing Director of the Company, for permission to read the paper and exhibit the samples.

The early history of the gas and dye industries reflects great credit on the engineers and the chemists of this country. It may be said that the British gas engineer obtained a long start on the chemist, and kept up a remarkable rate of progress during the last 120 years; whereas the latter, though he began to perform wonders about the middle of this period, did not maintain his brilliant successes, and, for the last 40 years, until the war started, has been allowing himself to be relegated to a position more and more subservient to his German competitor.

We are all proud of the immense developments of the gas industry which have taken place in the last forty or fifty years. These have resulted long since in bringing to the humblest homes of our villages, towns, and cities gas at a price which all can afford. One can, I think, safely go so far as to say that the consumption of gas per head of the population is an index to the prosperity and comfort of the bulk of the people. One cannot, on the other hand, say this about dyes; for while gas must be made on or near the spot where it is used, dyes and most other chemicals are easily transported, and therefore are liable to be bought in the cheapest market.

Gas Consumption in Great Britain and Germany.

I find difficulty in using the term gas, and was about to call it illuminating gas. But there are objections to the word "illuminating;" and "coal gas" is not always correct. Probably "town gas" is as good a term as any. To indicate the great superiority of Great Britain over Germany in the utilization of town gas—a superiority probably not generally realized—I would point out that the consumption per head of the population in these two countries is in the ratio of about 4 to 1. I well remember, some twenty years ago, a German professor of chemical technology admitting to his students, to his regret, that London consumed as much town gas as the whole of Germany. Another remarkable fact in this connection is that a few years ago, when the price of Birmingham town gas was, on an average, 1s. 7d. per 1000 c.ft., the corresponding price in Berlin was 4s. It was difficult to account for this big discrepancy, especially as Birmingham gas had the higher calorific value, and the net prices of coal after selling the coke were nearly equal. I do not happen to know the price charged per unit of electricity in Berlin in those days; but at any rate, we were pleased to learn that, in competition with its rival for street lighting, high-pressure gas had won the day. At the same time, Berlin was stated to be the best illuminated city in the world.

My next remark might not be quite relevant to my subject; but I do not wish anyone to get the idea into his head that there was no great need for town gas in Germany because electric lighting was more commonly in use, and that this represented a higher state of culture or civilization. I might say that when I was studying in Germany twenty years ago, over a period of four years, and in several cities, in no instance did I have the opportunity of using either gas or electricity for lighting purposes in my lodgings. There were no services of either in common use—quite a different state of things from what existed then in the home country. It was necessary there to use oil lamps for light, and methylated spirit burners for emergency or summer cooking; the bulk of the people could not afford the luxury of better and more convenient illumination and heating by means of gas.

This country, therefore, had a very great advantage, not only over Germany, but over all other countries in the potentialities of her coal-tar industry. The pity is that our business men and our statesmen did not discern its important bearing on our national defence and independence On the other hand, Germany has, in recent years, made up most of her deficiency in coal gas, and tar accompanying the same, by her very rapid development of the bye-product coke-oven, which is intimately connected with her steel industry. She carbonizes approximately 50 p.ct. more coal in this way than the United Kingdom; and thus her total supplies of coal tar and other bye-products have made her absolutely independent of this country, whereas she was formerly a heavy buyer.

Historical.

The story of the initiation of the dye industry has been frequently told since we began to feel the pinch after foreign supplies of dyestuffs were cut off. I may be allowed to recapitulate the leading events of this history. Although as early as 1792 Murdoch inaugurated the commercial application of coal gas, it was not till 1820 that any chemical discovery in connection with its bye-products was recorded, when Garden isolated naphthalene from coal tar.

Benzene was discovered by Faraday in 1825, in the oils condensed from "portable gas," which came into use in 1819 for a short period. A quantity is said to have been exhibited at the British Association meeting in Manchester in 1842; but its origin was doubtful. At any rate, Hofmann, in 1845, definitely succeeded in isolating it in the pure state from coal tar.

Aniline was discovered in 1826 by Unverdorben among the products of distillation of indigo, and derives its name from the word "Anil," Portuguese for indigo. Its existence in very small quantity in coal tar was proved by Runge in 1834; but it is a popular error to suppose that it can be extracted therefrom in commercial quantities.

Anthracene was isolated from tar in 1833 by Dumas and Laurent. Runge, a year later, obtained also carbolic acid, quinoline, and pyrrol. A process for making nitro-benzene, a product intermediate between benzene and aniline, was patented by Mansfield in 1847.

Though the early gas engineers for the most part looked upon tar as a nuisance or waste product, and would gladly have dispensed with its presence, yet as early as 1834 tar was distilled in Manchester for manufacturing varnishes. In 1848 Mansfield carried out the first systematic fractionation of coal tar, and isolated, in a more or less purified condition, the principal constituents known to the tar distiller of to-day. He prepared pure benzene and fairly pure toluene. In those early times, tar was very different from what it is now. It was comparatively rich in light oils, on which its selling value largely depended, and low in carbon content. These qualities were, of course, due to the low temperature of distillation then employed.

The greatest event of these times was Perkin's synthesis, in 1856, of the dyestuff aniline purple, afterwards called mauve. The isolation of this new colour—the first coal tar colour—was accidental, as this famous chemist was at the time vainly endeavouring to synthesize quinine by the oxidation of aniline. After overcoming obstacles and prejudices to the introduction of this artificial dye, the inventor took up the manufacture of synthetic dyestuffs at Greenford Green, London, towards the end of the year 1857. In 1859, magenta was introduced by Verguin. Hofmann's violet and various other dyes were put on the market shortly afterwards.

A very important event in the chemical world happened in the year 1869, when Graebe and Liebermann, in the course of their researches on anthracene, produced, as the final result of successive chemical reactions carried out stage after stage, alizarine—the essential portion of the colouring matter obtained from the root of the madder

THE

SOUTH METROPOLITAN GAS COMPANY

is now Manufacturing,

and is able to give Prompt Delivery of,

DRY NEUTRAL SULPHATE OF AMMONIA.

TRADE MARK.

This Material possesses Special Characteristics:—

It is dry, resembling silver sand; it neither cakes together nor does it require grinding.

It will not absorb atmospheric moisture.

It may therefore be strewn on the soil as grass seed, or may be readily drilled into the soil.

It is neutral and does not destroy the bags in which it is transported or stored.

It is guaranteed to contain 25½% of ammonia; usually it tests from 25·6 to 25·7%.

A typical analysis of the material is:—

Ammonia	25·65%
Moisture	0·03%
Free Acid	NIL
Equivalent Nitrogen .	21·10%

For Prices apply to the

SOUTH METROPOLITAN GAS COMPANY,

709, Old Kent Road, LONDON, S.E.15.

Telegraphic Address: Inland—"METROGAS, PECK, LONDON." Foreign—"METROGAS, LONDON."

"CUIRASS" PAINT

ANTI-CORROSIVE. ACID-RESISTING.
CANNOT OXIDIZE.

Railway Girders in India painted four years ago reported by Engineer to be as good as when treated.

Vessels treated with "Cuirass" Paint will stand 50 per cent. solutions of sulphuric acid and caustic soda.

"CUIRASS" PAINT (Black only).

Unaffected by atmosphere.
Costs less than ordinary paint.
Covers more surface.
Takes less labour to apply.
Lasts longer.
Stops electrolysis, being good insulator.

Particulars and Prices from--

CUIRASS PRODUCTS, LD.,
39, VICTORIA STREET, S.W. 1.

THE
HEWITT CONSTRUCTION
SYNDICATE, Ld.,
Gas and Chemical Engineers and Contractors.

Gas and Chemical Plant.

Dehydration Plant (Hiller and Ball's Patent), Continuous and Non-Priming; Benzol Extraction Plant (Lessing's Patent); Rectification Plant for Light Oils producing Motor Spirit without Acid or Alkali Washing.

Retort Setting.

South of England Agents for Messrs. Bates & Cook, of Leeds.

Steaming Retorts (Horizontal)

on Whitcher's System.

Manual Charging Machine.

The "Dunkeld"—first and best.

Valves.

Renewable Seated Wheel Valves, Steam Jacketted Cocks, &c.

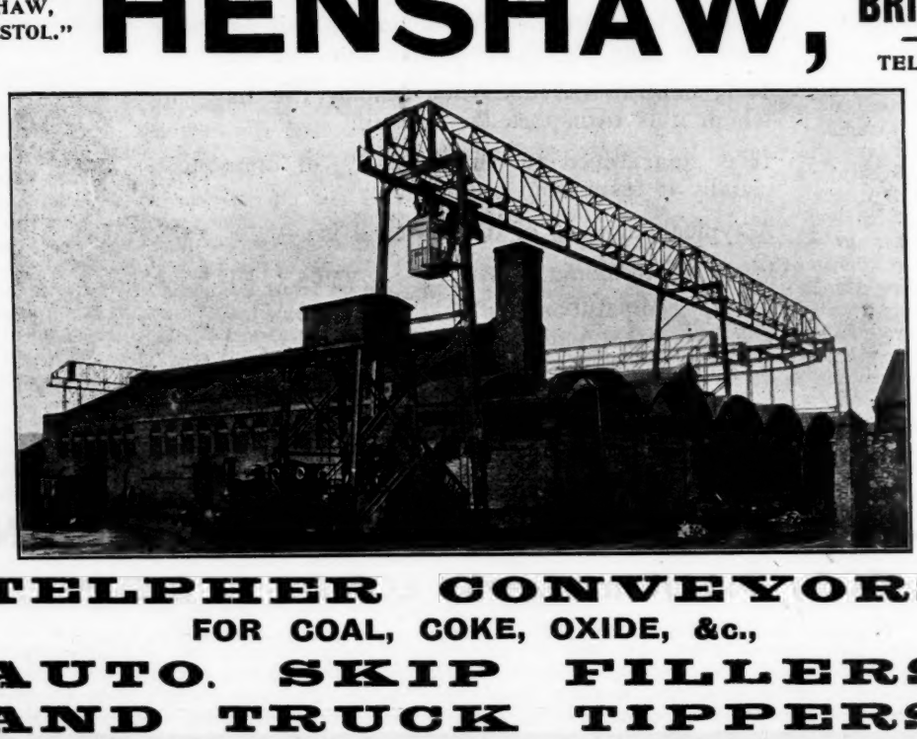
Balata Belting, "Pullata" Brand.

39, VICTORIA STREET, S.W. 1.

STRACHAN & HENSHAW, LTD., BRISTOL.

Telegrams: "STRASHAW, BRISTOL."

TEL. 432.



SPECIALITIES.

TELPHER CONVEYORS
FOR COAL, COKE, OXIDE, &c.,
AUTO. SKIP FILLERS, AND TRUCK TIPPERS.

SPECIALITIES.

plant. This was the first synthesis of a naturally occurring dyestuff. Its production—one cannot call it discovery, because one cannot discover something which is not there—was not due to accident, but was the result of systematic investigation, carried out in a purely academic or scientific spirit. The result was contributed to by other chemists who had discovered alizarine in madder root, on the one hand, and had investigated anthracene compounds on the other.

This dye, which is capable of dyeing cotton a bright colour—Turkey red—is one of the oldest dyestuffs employed by man. Fifty years ago, about half-a-million acres of land in different parts of the south of Europe were devoted to the cultivation of the madder plant; and the product was estimated to have the annual value of £4,000,000. This industry has long since, but not until persistent efforts were made to improve the artificial manufacture, passed into the hands of the coal-tar chemist. In 1913, over 3000 tons of alizarine and other anthracene dyestuffs were imported into this country.

It is acknowledged on all hands by chemists that this, and many other, advances in organic chemistry would hardly have been possible but for Kekulé's theory of the constitution of the benzene (aromatic) class of compounds which came as it were as a revelation or inspiration in the year 1865. With slight modifications, it still holds the field. From about this time onwards, organic chemistry made enormous strides. Light was thrown on the constitution or molecular architecture of primary compounds previously familiar to the chemist only in regard to their properties and elementary composition. From the careful study of the constitution of an aromatic body, it became possible to predict the formation of a great many derivatives of the substance, and eventually even to tell their colour and their properties.

An enormous field of chemical research was opened-out for the patient, plodding worker; and it proved eventually a very lucrative one. At the present time an account of over 100,000 organic compounds has been compiled; and the literature on the subject is so great that it would be impossible for anyone to read it once through in a hundred years, reading every available hour of the day. Thousands of chemists are adding to this pile of information every day. True, a very large proportion of the new work is only of theoretical or academic interest; but here and there, even in the Universities where no utilitarian spirit prevails, discoveries of commercial value are made.

The result of the creation of this immense field of work is that a worker must specialize to have any chance of success. To roam all over the field is in most cases aimless and foolish. Unfortunately, our chemists and leaders of chemical industry left the specialization almost entirely in the hands of the Germans, who turned their discoveries, as well as those of other people, to such good account as to give them practically a monopoly in dyes and other fine chemicals. The result was that for many years before the war began somewhere about 90 p.ct. of the dyes used in this country were of German manufacture. It was not the value of the dyes imported into this country (then roughly £2,000,000) that mattered so much as the possible effect of cutting off these supplies from the great textile industries, which represented a value, at pre-war prices, of about £200,000,000 per annum. These great industries would be absolutely strangled if the supply of dyestuffs were entirely to fail. Fortunately, the few dye undertakings that had kept pegging-away as best they could were able to come to the rescue when war broke out, and, with Government assistance, saved the situation from dire extremes. The eyes of the leaders of this country have been opened, let us hope, clearly to see the paramount necessity of fostering and encouraging in every way industries so essential to the life and independence of the country as these under review.

Causes of British Want of Progress in the Dye and Fine Chemical Industries.

This subject has been often discussed in public, particularly during the last few years. Some authorities blame our old patent laws, and are far from satisfied with the existing ones; others blame the former restrictions on the manufacture and sale of industrial alcohol; some lay the entire blame on our industrial leaders, the capitalists, who had no real sympathy with scientific pursuits, and could not see beyond their noses; others, again, attributed our misfortune to lack of general education, especially of scientific and technical education; and, finally, I would mention, with respect, the judgment of Lord Moulton, who has carefully studied the whole question. At Manchester, in December, 1914, speaking of the decline of the British Dye Chemical trade, Lord Moulton said: "We have got to look the truth in the face. It was for no other reason than the English dislike of study. The Englishman is excellent at making the best of the means at his disposal. But he is almost hopeless in one thing. He will not prepare himself by intellectual work for the task he has to do." Again, "As to coal, and the sources of coal-tar industry, we have them in richer quantity than even Germany herself. The one thing is a difference in the human element; and this is not a difference in intellectual capacity, but in the industry and the willingness to study to the bottom the subject with which you have to deal."

Most of our learned professors of chemistry who have spoken on this subject disclaim any lack of chemical ability or talent in this country; and they point to the ever-increasing amount of research work published in the English journals as an indication that chemistry is fully alive. It is quite true that more research work is turned out by chemists than by all the other scientists combined in this country. The late Sir W. H. Perkin, on the other hand, who sold his dye factory in 1874 after a successful business career of 17 years, stated that one of the causes which influenced him in returning from industry to private research was the dearth of suitable chemists. At this time England held a pre-eminent place in the manufacture of dyes, with France in the second place. It is generally agreed that the managers of English works are too often satisfied with rule-of-thumb methods, and attach more importance to the foreman who knows how to run a process than to the chemist, who perhaps may not know how to handle workmen but, if he is the right sort, is more likely to make progress. Judging from the small number of well-qualified chemists employed in chemical works, there appear to have been ample grounds for the complaint of those who bewail the divorce of science from industry.

In my opinion, the main difference between a British and a German chemist is often overlooked. The former, as a rule, trains mainly to pass written examinations, does not read widely, and is not interested in research; the latter is brought up in a much more independent fashion, and is obliged to carry out research for at least eighteen months—more usually for two years—before he can qualify for his degree. You find the average chemical student in the German university or technical school working in the research laboratory from 8 a.m. to 6 p.m.; and a single professor is able to direct the research work of as many as thirty chemist students at one time, in addition to his own private work. Most of the German university graduates in chemistry go straight to the chemical-works after finishing their course. There they become specialists, either in some line of research or in a works' process. Some of the principal works in Germany employ a very large number of chemists—in some cases as many as 250 research chemists; the principal men getting very handsome salaries. One can safely say that, in comparing the total numbers of research chemists in each country in the year 1913, there were about twenty in Germany for every one in the United Kingdom. Some say we can never hope to recover the leeway we have lost, and in any case it is only natural and right that different countries should specialize in different departments of industrial activity; further, that the German temperament is specially adapted for the peculiar conditions attending chemical research and complicated chemical processes.

The British manufacturer must be reminded that it is profitable to court science. Those large German chemical companies, in spite of, or really because of, their formidable outlay on research, have made huge profits; for not only have they paid 25 to 30 p.ct. dividends for many years, but they have also written-off their plant costs to a remarkable extent. Three notable instances may be mentioned where the results of research, engineering as well as chemical, have brought great rewards.

The first is the development of the platinum contact process for making sulphuric acid. The necessity of producing a cheap acid of high strength, as well as fuming acid, formerly called Nordhausen acid and now generally called oleum, first arose when attempts were made to put synthetic alizarine on the market. Since then there has risen a great

demand for concentrated and fuming sulphuric acid for a variety of purposes. To gas engineers it is most interesting to study the conditions required to ensure success in this process. When using sulphur in the burners, there is comparatively little difficulty. But the use of sulphur being prohibitive commercially, it was necessary to use pyrites; and it was soon found that the merest traces of dust—arsenic, iron oxide, or lead sulphate, &c.—passing forward in the burner gases stopped the catalytic action of the platinum mass and brought the plant to a standstill. After toiling through years of partial failure, ways were found to ensure complete success. The design of such plant is a matter of the greatest importance, as it is possible to spend huge sums of money on a large factory, and still not achieve success; and for many years the details of the process were kept secret. The cost of oleum in Germany was reduced to less than one-tenth of what it was formerly manufactured at by the old processes; and even for 90 to 95 p.ct. acid the cost compares favourably with that of similar acid made by the chamber plant and concentrators.

A second instance is the very remarkable development of artificial indigo. As far back as 1880, Baeyer synthesized indigo from toluene. This process was not a commercial success, though the achievement was of the highest scientific importance. Besides, there was at that time insufficient toluene available to make enough indigo to entirely displace the natural article. Ten years later, Heumann discovered a new method of synthesizing indigo, and used as his starting point naphthalene, of which there is an abundant supply in coal tar. There are seven stages in the process, and some of them are attended by serious difficulties. The difficulties were, however, sufficiently surmounted as to make the manufacture a commercial success. It was Heumann who also afterwards discovered a third method of making indigo. In this case benzene is the primary substance; and here, again, there is abundance of material. This method was successfully developed by Meister, Lucius, and Brüning, whose indigo works at Ellesmere Port were taken over by Levensteins, Ltd., two years ago. Another large German company has a rival process in which the starting point is not coal tar, but the common potato, or any other cheap source of alcohol.

The natural indigo, the production of which was formerly valued at £4,000,000 per annum, has to a large extent been driven out of the market by the low-priced synthetic article. It was highly probable that, as soon as the Germans succeeded in driving competition completely off the field, prices would be put up, and importers would be made to pay through the nose for this indispensable dye. It is said that the Germans spent altogether about £900,000 in bringing out this important dyestuff. The whole story of indigo is one of foresight, perseverance, enterprise, and resourcefulness; and it reveals the implicit confidence which the Continental manufacturers had in the ability of chemists and chemical engineers.

The manufacture on a large scale of Haber's synthetic ammonia is another wonderful instance of a victory won by dogged perseverance and skill in attempting the seemingly impracticable task of bringing about the combination of nitrogen and hydrogen in vessels maintained at a red heat, and working at the same time at pressures exceeding a ton per square inch. The commercial success of this process was proved in 1913. It dovetails into Oswald's simple and efficient process for making nitric acid from ammonia, and renders the country of its adoption more independent than ever of the supplies of nitrate of soda coming from Chili, seeing that the manufacture of synthetic nitric acid made from the atmosphere was also in successful operation. Whether or not the manufacture of synthetic ammonia will materially affect the price of sulphate is an anxious one for the gas industry. At present, it is too early to pronounce judgment. The world's demand for combined nitrogen in some form is bound to keep on increasing to such an extent as to ensure a ready market for all that can be made. It is also hopeful to learn that agriculture is to receive special encouragement from the State.

Essential Industries.

The question arises: What are the industries which a country like ours, for the sake of its independence, self-preservation, and defence in time of war, is practically compelled to develop or nurse? Hitherto, our command of the sea has given us a sense of security, and served perhaps to damp the ardour of those who might be inclined to launch upon new ventures, such as those referred to. The feeling of security, however, is not so strong as it once was; and many think it is now time for our Government to adopt a more paternal attitude towards the industries of the country. The dye industry must certainly be classed as essential, and, in my opinion, also the gas industry, with which must be linked coke manufacture, with the recovery of the bye-products of coal distillation. There has been much discussion at headquarters lately about the conservation of our national resources of coal supplies, and great schemes have been propounded for the production of steam direct from raw coal for the running of huge turbines generating electricity. Now, although the supply of the primary materials necessary for the manufacture of dyes and other chemicals is at the present time abundant, or can readily be increased by simple processes of fractionation, absorption, and purification, it is not to say that this state of things will continue as chemical industry develops. One must also not forget the possible demand for benzene, toluene, and carbolic acid, and perhaps naphthalene for the making of explosives.

True, the discovery of large quantities of toluene in certain petroleum wells in the Far East in the early days of the war—a discovery utilized by the Germans a good many years ago, I believe—eased the situation as regards that important hydrocarbon. But oil wells have a way of petering-out, and are therefore not to be depended upon. It may be said we will be able to get all we want from the cracking of oils. Here, again, we would be dependent upon foreign supplies. At all events, it is wise for a nation to take all possible steps to ensure an adequate supply of these essential articles by tapping different and independent sources. Moreover, every one knows the importance of a native supply of large quantities of any and all kinds of light, middle, and heavy oils for motor traffic and for the Navy. Again, ammonia (or at any rate some form of combined nitrogen) is a national necessity for food production. It will also be used more and more in chemical industry. In combination with nitric acid to form nitrate, ammonia may be looked upon as high explosive. Immense quantities were used during the war to produce a mixture with T.N.T. for filling shells, thereby materially increasing the available quantities of high explosives, and greatly reducing the cost of the shell-filling mixture.

There are other bye-products of the gas industry which may be considered essential to the nation's welfare—particularly cyanogen compounds and sulphur. Altogether, without going too much into details, a strong case can be made out for the indispensability of the industries which distil coal and recover the various bye-products of distillation.

Manufacture of Intermediates and Dyes.

It is apparently still a popular delusion to suppose that artificial dyes are produced by some sort of magic process from the repulsive substance known as coal tar. A short time ago, the daily papers announced the discovery or purchase in Switzerland of 200 or 300 so-called recipes for transforming that uninviting substance into as many beautiful fast dyes of all colours and shades. The man in the street seemed to swallow the tale, and heaved a sigh of relief as he felt that we had wormed these valuable secrets from the Germans. The average Briton is so lacking in scientific knowledge that he is quite unable to discern in such matters, and even the well-to-do or would-be investor is often an easy prey to the company promoter or financial adventurer.

Perhaps it is too much to expect the average business man to take full account of the heavy cost of chemical plant, depreciation, efficiency, establishment charges, and such like. Gas engineers know full well what these things mean. One of the most astounding, and at the same time amusing, promoters' prospectuses that ever came under my notice was one of recent date. The proposal was to put down carbonizing and distilling plant to deal, as a first instalment, with 100 tons of coal per day. Now note the prospective results of the processes intended to be carried out:

Products for Sale per Ton of Coal Carbonized.

15 cwt. of special coke.	2 lbs. methyl violet.
45 lbs. of sulphate of ammonia.	12 lbs. naphthol yellow.
10,000 c.ft. of gas.	8 lbs. scarlet.
1 lb. magenta.	1½ lbs. orange.
	3 lbs. Turkey red.

This was not to be a low-temperature process, mark you

for the coke was to be special metallurgical. Presumably various plants would be erected for the manufacture of the above-mentioned dyes, which have as their primary sources, respectively, benzene, toluene, naphthalene, and anthracene; but, as calculated from the sinking-fund charge laid down in the balance-sheet, the whole cost of the plant, including the complete gas-works, was only £64,000. I must not trouble you with details; but as some of the dyestuffs fetch as much as 20s. per lb., and the estimated cost of production on paper allowed nearly 500 p.ct. net profit, you will not be surprised to learn that the net profit, after making allowance for all sorts of expenses, including directors' fees, commission, and bad debts, was to come to nearly £1800 per day, or about £18 per ton of coal carbonized. Whether the promoters of this marvellous scheme got the necessary money, I cannot say. I should not be at all surprised if they did. If they have not gone on with the work, the likelihood is that it was the imposition of the excess profits duty that stopped them.

The fact is, it is a long cry from coal to methyl violet, magenta, and dyestuffs in general. The plant necessary for production is both costly and complicated. The manufacture generally proceeds through several intermediate stages, each of which requires great care; and the yields in most cases are by no means equal to what one would theoretically expect. Besides, many of the reacting chemicals that have to be brought into play are difficult to manipulate and expensive. Huge quantities of sulphuric acid have to be employed. In fact, the oleum plant is generally the largest and most costly plant on a modern dye-making works. Acid has to be supplied of twenty different strengths, up to the strongest oleum; and as the last-mentioned freezes at summer heat, it requires special handling. Sulphuric acid is used partly in splitting, partly in nitrating (in combination with nitric acid), but mostly in sulphonating. In the latter process, quantity, pressure, temperature, strength of acid, and duration of action have all to be studied, and the specified procedure strictly adhered to if one is to get the best results. Nitric acid of various strengths is used in large quantities, chiefly for nitration. Here, again, the results depend on the careful carrying out of the working conditions. These two acids are the principal ones employed in making dyes, and the only ones that are required in the comparatively simple operations of converting phenol into picric acid (that is to say, lyddite) and toluene into trinitrotoluene (T.N.T).

The commoner chemicals—lime, salt cake, nitre cake, soda ash, caustic soda, chlorine, bisulphite, hydrochloric acid, acetic acid, chlorosulphonic acid, ammonia, sulphur, and the more expensive potassium salts, zinc, tin, mercury, bromine, iodine, methyl alcohol, ethyl alcohol, formaldehyde, phosgene, tartaric acid, and, dearest of all, platinum—find their various uses in the manufacture of dyes. When the works are on a sufficiently large scale, great economy can be effected by recovering and working-up the bye-products, and by concentrating weak waste acids, especially sulphuric acid, after they have done their work.

Frequently the bye-products of the manufacture of one chemical conveniently satisfy the requirements of another process, and the two processes become mutually helpful. A well-established complete dye factory is necessarily a huge concern, requiring a large amount of capital to be invested in plant, upon the design and quality of which a great deal depends. If there is any doubt in an expert's mind about the likelihood of immediate success attending the efforts of British undertakings in building-up a large trade in the dyes and fine chemicals already known to science, it is not on account of lack of laboratory knowledge and skill, but on account rather of inexperience in the designing of the best types of plant and working them to the best advantage. Not that it always pays to increase the efficiency of a reaction from (say) 90 to 95 p.ct. for example, as the extra cost of plant for doing so, and the capital charges thereon, may be prohibitive.

Very elaborate and costly plant is often required in the manufacture of the products of the first stages in the process of dye manufacture—the chemicals known as intermediates—whereas the actual production and separation of the resulting dyestuffs are usually achieved with comparatively simple apparatus. If one examines figures making up the cost of producing dyes or fine chemicals, or even oleum, one cannot fail to be struck with the relatively heavy proportion of cost due to amortization, as compared with materials or, particularly, labour. The charges for the sulphuric acid contact process of a certain type, for example, are roughly in the following proportions:

	Per Cent.
Materials (pyrites)	35
Amortization, rents, rates, taxes, insurance	45
Process labour	8
Repairs, labour, and materials	6
Other charges	6
	100

Other examples might be given to show that in a chemical works making dyes and allied chemicals the main thing is the plant—labour charges being a secondary consideration. The manufacture of coal tar products and their derivatives may seem to some gas managers an attractive proposition. There is the idea, perhaps, of the existence here of a hidden gold mine. My opinion is that while every encouragement should be given (even to the extent of Government subsidy) to the production of the well-known primary aromatic hydrocarbons, including especially benzene and its homologues obtained by gas washing, the setting-up of plants to go a step further—that is, as far as intermediates—is too risky for gas manufacturers to undertake, except in special cases.

Constituents of Coal Tar Necessary for Dye Making.

Although as regards the number of different organic compounds (about two hundred) contained in ordinary coal tar there may be said to be a splendid choice, only half-a-dozen or so are of commercial importance. These are benzene, toluene, xylene, phenol (carbolic acid), naphthalene, and anthracene. The first three liquids have fairly low boiling points and high vapour tensions, and their vapours are therefore readily carried forward in the large volume of permanent gas which they accompany in the process of gas making. Were it not for the circumstance that the bulk of the tar drops out of the gas in a hot condition, a larger amount of light oils would be left in it. As it is, there is usually about twenty times as much benzene and toluene retained in the gas made by carbonizing a ton of coal as is contained in the tar recovered therefrom as a bye-product. It is only in recent years that this fact came to be realized by chemists. All my old organic text-books, for example, mention coal tar as the only commercial source of benzene and toluene. It is an instance of the teacher being out of touch with industry.

It would be useful if one could say with some degree of accuracy how many tons of each of these primary products are likely to be required per annum in this country for the purpose of dye making. But this is hardly possible. The gas manager has already had experience of the fluctuations of the tar market, and has had his share of disappointments in the prices realized. The fact is that the price, as a rule, depends far more on the pitch and creosote markets than on the demand there may be for anthracene, naphthalene, and carbolic acid.

To give some idea of what our tar distilleries may be expected to do, I may be allowed to cite the record of the coal tar products turned out by German tar distilleries in 1908 and 1909. (Lunge. "Coal Tar and Ammonia," p. 35.)

	1908. Tons.		1909. Tons.
Tar pitch, including soft pitch	402,700	..	455,200
"Prepared tar," distilled tar	83,710	..	91,520
Heavy tar oils, including carbolic oil, creosote, naphthalene oil	248,100	..	287,900
Naphthalene crude	19,710	..	23,730
Naphthalene, pure	16,680	..	13,500
Anthracene crude and pure, all calculated as pure anthracene	4,026	..	3,548
Pyridine bases	385	..	336
Phenols, cresols, &c.—			
a. Crystallized carbolic acid	1,000	..	2,211
b. Cresols, so-called 90, 95, or 100 p.ct. carbolic acid	2,081	..	2,665
c. Crude phenols for sale	581	..	604
Benzol, crude, purified, and pure	13,230	..	19,120
Toluol, crude, purified, and pure	2,601	..	2,791
Xylol (solvent naphtha, heavy benzol, crude and purified)	4,717	..	5,011
Other products of tar distilleries	4,160	..	9,008
	803,700	..	917,100

Still more instructive are the returns published in the

"Chemische Industrie" for the coke-oven bye-product industry of the Dortmund district (Rhineland). These were:

—	1910.	1911.	1912.	1913.
	Tons.	Tons.	Tons.	Tons.
Tar	515,300	570,000	699,100	686,100
Tar-pitch	68,880	90,860	110,900	134,700
Crude naphthalene	7,954	9,855	13,860	12,820
Anthracene	2,382	2,403	3,354	3,404
Crude benzol	28,050	36,580	35,020	31,270
90 p.ct. purified benzol	27,090	30,910	45,570	83,370
Crude toluol	2,584	2,302	2,585	2,115
Purified toluol	794	1,656	3,910	6,582
Crude xylol	1,483	1,536	1,927	1,981
Solvent naphtha, crude	867	1,571	1,933	2,437
" " purified	..	..	6,437	9,520

The extremely large increases in production of benzol and toluol in 1913 are very remarkable and suggestive.

Quoting again from Lunge's "Coal Tar and Ammonia," we find the production of benzol in different countries for the year 1907 estimated as follows:

	Tons.		Tons
Germany	60,000	France	8,000
Great Britain	25,000	Belgium	6,000

The annual sales of the German Benzol Association were at that time:

—	1906.	1907.	1910.
	Tons.	Tons.	Tons.
To colour works	23,663	29,637	32,300
To gas-works	1,487	1,240	928
For other purposes	6,121	10,511	1,240
			33,322*
Total	31,271	41,388	67,790

* For motors.

Another estimate showing the tremendous strides made by Germany in the recovery of benzol is given in the following tonnage figures for total production:

1896.	1904.	1908.
4,000 ..	40,000 ..	90,000

As for the production of gas and tar bye-products in the United Kingdom, only meagre statistics are available. Recently published figures show how great was the service rendered during the war by the coke-oven and gas industries. Converting gallons into tons for the sake of comparison, the following may be quoted:

Tons of Crude Benzol from Coke-Ovens.

1914.	1915.	1916.	1917.	1918.
86,100 ..	99,000 ..	122,400 ..	132,100 ..	126,600

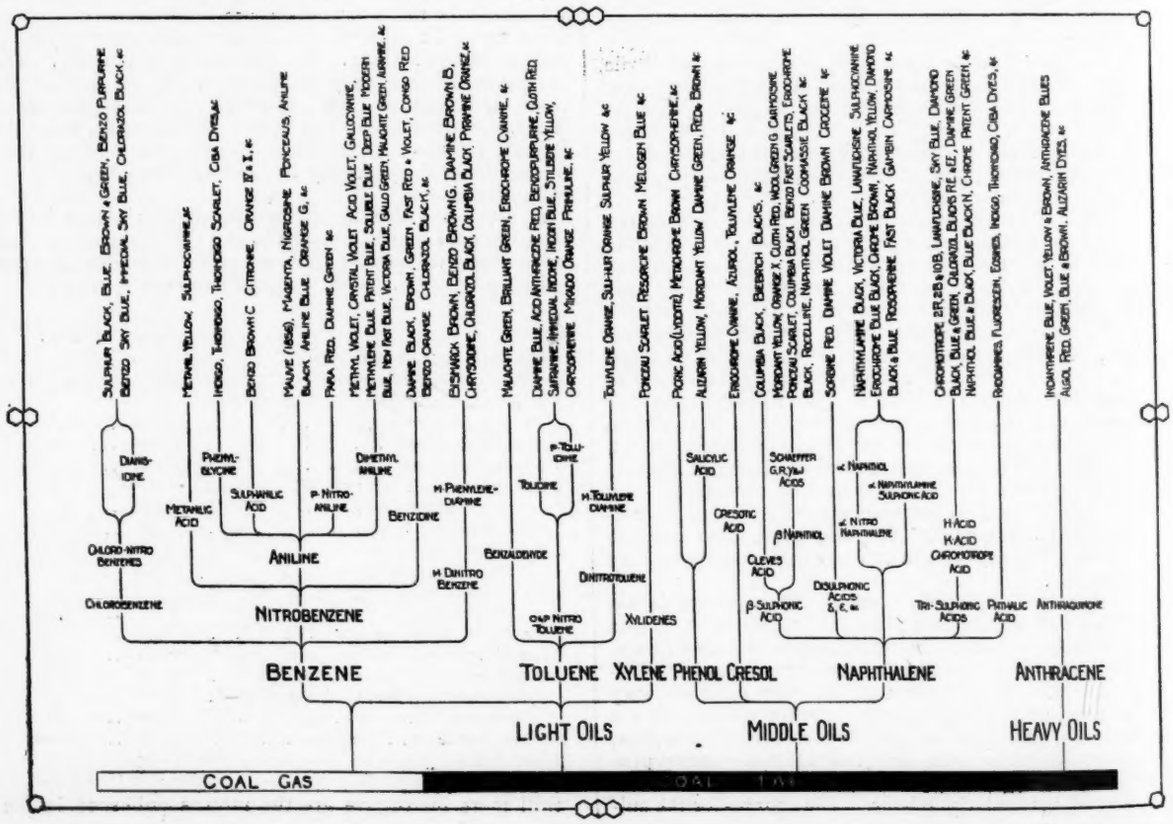
Approximate Production of Benzol Products from the Gas Industry during the War (say, in Three Years).

	Tons.
Pure benzol	86,000
Pure toluol	31,000
Pure solvent naphtha	16,000

For many years the demand for benzol for gas-works for carburetting has kept dropping off, until now it is probably insignificant. During the war, on the other hand, many thousands of tons of benzene were converted into phenol for the manufacture in this country of the high explosive, picric acid. Our ally, France, also imported large quantities for the same purpose. There is probably insufficient demand for synthetic carbolic acid to warrant the continuance of the manufacture; the quantities to be obtained from coal tar being sufficient in ordinary times. One can also say with some assurance that it will not be necessary to separate the toluene fraction from the benzene to anything like the same extent as during the last four years. The demand for pure benzene, toluene, phenol, and anthracene for colour making will naturally depend on the rate of progress of the revivified industry.

It is not at all likely that the price of tar will be appreciably improved by the demands of the dye industry—at any rate, for a good many years to come. The value of the whole of the coal-tar products used by the German dye industry in any one year probably did not amount to much more than £500,000. The derivatives made therefrom were formerly valued at £12,500,000 per annum, of which finished products to the value of £10,000,000 were exported every year.

Closely allied to, and almost inseparable from, the manufacture of dyes are the industries of synthetic drugs, perfumes, and photographic chemicals. Every dye-making factory is almost bound to take up the manufacture of some of the well-known drugs and other fine chemicals. The value of these industries to Germany was very great, representing, in products sold, several million pounds per annum. Most of these products—such as the well-known drugs, kairine, antipyrine, antifebrine, phenacetin, aspirin, suprarenine, salvarsan, saccharine, &c., as well as such perfumes



as coumarin (discovered by W. H. Perkin in 1868), vanillin, heliotropin, &c., and the photographic developers hydroquinone, metol, amidol, &c.—are derived from aromatic hydrocarbons obtained from coal gas or coal tar.

It would be an impossible task to describe even the more important commercial derivatives of coal tar products—reference to the accompanying diagram will give some information as to their relations one to the other.

With all due deference to the skill and labour of those who have, for many years, searched for the hidden treasures of coal tar, I would say, in conclusion, that there is good reason for believing that further efforts will disclose primary products which will be turned to good account in the service of mankind.

Dr. Davidson Thanked.

The PRESIDENT: I have great pleasure in moving our heartiest thanks to Dr. Davidson, a member of the Institution, for coming forward so readily and giving us his instructive and interesting address this morning, and to the Company who have allowed him to bring these samples, and gave him, as he says, a free hand in passing on to us the information as he has done so well. [Applause.] Dr. Davidson, this applause is in some measure an expression of our hearty thanks to you; and will you convey for us to your principals our thanks for the freedom they have given to you to help us.

Dr. DAVIDSON: I will certainly convey your appreciation to the proper authorities. I may say that our Directors are not at all conservative or exclusive; and if any of you at any time wish to see our new works, you will be heartily welcome. I do not say that you would see everything; but the principal plants will be open for your inspection. As regards myself, I have not lost interest in gas engineering. In fact, I have to manage a Mond producer gas plant; and we do all our drying by gas. On our new works, we have 120 simple furnaces, without regenerators, because we do not want at present very high temperatures; and that is all done with gas. In this connection, I want to thank Mr. Arnold, who is a trained gas engineer, whom we got from Birmingham. It has been a pleasure to me to get this paper together.

A Message from the Italian Association.

The PRESIDENT: The following message has been received from the Italian Association of Gas and Water Engineers:

> **On the occasion of your first general meeting after our splendid united victory, send to you, our honorary member and colleagues, sincere greetings and wishes that coming peace may fortify old friendship which ties Italy to England.**

It will be your wish that a suitable message be sent to our colleagues in Italy, in answer to this.

The proposal was received with acclamation.

The following paper was then read.

THE APPLICATION OF REINFORCED CONCRETE TO PURIFIER CONSTRUCTION.

By A. E. BROADBERRY, M.Inst.C.E., of Tottenham.

The desire to construct purifiers in reinforced concrete had been present in the mind of the writer for a considerable number of years. It is only recently, however, that the opportunity came to put the desire into execution; and the concrete purifiers at Tottenham appear to have attracted sufficient attention to make a paper on the subject of interest to members of the Institution.

It is somewhat difficult to attach an exact date to the birth of the idea; but it certainly grew out of the erection of a set of six cast-iron overhead purifiers in 1896. These purifiers were arranged in two boxes, 120 ft. in length and 36 ft. in width; the length being subdivided by two cross partitions so as to form three purifiers each of 40 ft. by 36 ft. Each purifier had four covers, 14 ft. by 12 ft., arranged between the permanent cast-iron decking which served as gangways, on the principle introduced two or three years previously by Mr. Henry Green, then the Engineer of the Preston undertaking. There was no concrete actually used in the purifiers; but between and surrounding them additional decking was constructed in reinforced concrete, supported on concrete walls, which were cast *in situ*. The natural result was that very soon the question arose: "Why did we not do it all in concrete?" The elimination of the old-fashioned water-lute made the problem so easy that the idea soon became a firm conviction that we would have done well, and saved considerable money, if the whole construction, instead of being in cast-iron supported on steel joist framework, had been made entirely in concrete. The boxes being overhead, every part was accessible for giving attention to any possible faults that might have developed; and the more the idea was discussed the more convincing it became that it would have been the right course to adopt.

With the building of an entire new section of the works, which was first contemplated in 1910, but not started until 1914, the opportunity came at last. The purifiers for this section had to be designed for dealing with a make of gas of five million cubic feet per day. An experiment of this size was sufficient to make almost any board of directors hesitate, and cause them to pause and think. Fortunately, however, Tottenham possessed a progressive Board, consisting largely of expert engineers, with the late Sir Corbet Woodall as its Chairman. The principal risks in connection with the proposal appeared to be (*a*) the possibility of minute fractures due to expansion and contraction from changes of temperature and varying pressures of gas in the boxes themselves; (*b*) the imperfect joints between the concrete where the work had to be left (possibly sometimes for days) between the time when one stage of the work had to be stopped and the next stage commenced [this, as is well known, is always a source of weakness in concrete construction]; and (*c*) the possible porosity of the concrete itself.

In consideration of the first-mentioned risk, it was decided to subdivide the five purifiers, making them in three boxes, as shown in fig. 1, two of the boxes being arranged as twin purifiers, and the third box separate to be used as a catch purifier. The internal measurement of each purifier is 56 ft. 1 in. by 42 ft. 6 in.; so that the greatest length of concrete liable to temperature changes was 88 ft. externally, and no great risk was considered likely from expansion and contraction in this length. In order to overcome the second objection (the imperfect jointing between various stages of the work), it was proposed to make the casting continuous. This, however, was subsequently found to be impossible. But the reason for the intention was fully instilled into the contractors, and special care was taken to secure the best possible cohesion of the work, particularly at the jointing.

It may, however, be mentioned, at this stage, that the few very slight defects which have developed (which are not sufficient to constitute leaks) are clearly traceable as occurring only at these joints. In order to guard against the possible porosity, the interior of the purifiers in each case was treated with three washes of "Ironite." It is now somewhat regretted that one box at least was not tried with the concrete untreated, so as to ascertain whether or not this safeguard was really necessary. Indeed, if time had permitted, it would have been very interesting to have tested other safeguards—as dressing with hot tar, tallow, paraffin wax, or other similar material to overcome any possible permeability. However, the concrete dressed with Ironite has proved itself to be quite impermeable, except (as already stated) in a few very slight cases at the joints of the work. These slight defects will be treated on the inside with a mixture of hot tar and pitch.

DETAILS OF CONSTRUCTION.

Having settled the general lines, and become convinced that the principle was sound, the work was sanctioned by the Board, and details of construction proceeded with. This naturally necessitated, first, a study of stresses, particularly those that do not enter into calculations for reinforced concrete constructions of the ordinary kind. The most important of these extraordinary stresses are those due to the pressure of the gas. It was assumed that 48 in. would be the maximum; and this in itself constitutes a considerable additional load, as may be realized when we consider that 48 in. pressure is equal to $1\frac{3}{4}$ lbs. per square inch. At this pressure the floor load is increased by 266 tons in each purifier, equal to a ton per square yard. This portion of the load does not, of course, affect the foundations or supporting stanchions; but it must enter into all calculations for floor structure, including the main and secondary beams.

The same pressure acts as an upward stress on the decks and covers of the purifier; and as the top is divided into four openings for the lids, the stresses on the decks and gangways are severe.

In order to provide sufficient strength, advantage may be taken of the coamings surrounding the cover openings; and they can be utilized as inverted beams. Then, again, the interior stanchions which support the decking round the four cover openings of the purifier when it is not at work can be brought into service, and, in fact, must be designed to act as ties between the floor and the gangways when the roof is subjected to the upward pressure (fig. 3). The pressure on the sides can be dealt with fairly easily; but being uniform from bottom to top, the reinforcement is different from that required for the sides of a water-tank, where the pressure is at its maximum at the bottom and zero at the top. The deck surrounding the outside of the cover openings has to serve as a horizontal girder to resist the outward pressure on the sides at the top, and provision must also be made to secure the sides firmly at their junction with the floor (fig. 4).

The main beams have a span of 21 ft. 8½ in., with a total depth of 33 in. (fig. 5). The secondary beams have a span

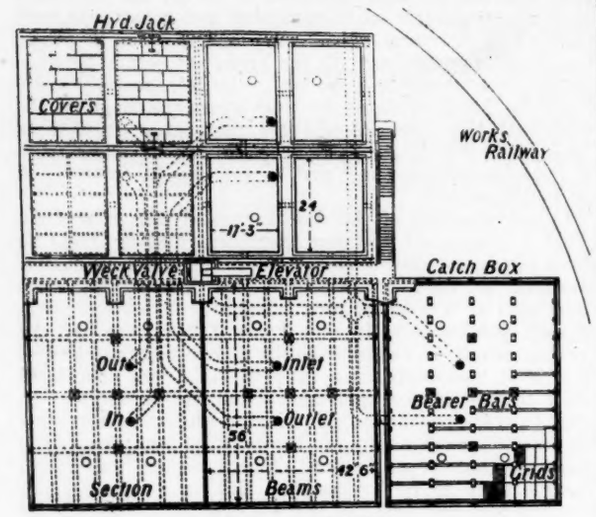


FIG. 1 PLAN

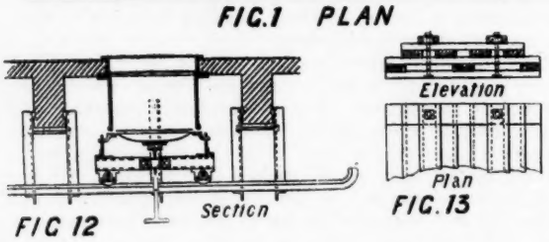


FIG 12 FIG. 13

of 14 ft. 3½ in. They are 21 in. deep, and are spaced 5 ft. 5 in. centres (fig. 6). The floor slab is 5 in. thick (fig. 7). The decking and gangways are 6 in. thick, and the sides 7 in. thick. The sides were made thus thick for constructional reasons, not merely for strength. The stanchions (fig. 8) are 15 in. square for the interior, and 13 in. for the exterior. They are strongly reinforced, and have to carry a dead-weight load of 54 tons and 36 tons respectively. They rest on mass concrete foundations 5 ft. square, carried down to firm ballast, and are brought to a uniform level 8 ft. below the ground.

THE COVERS.

The next matter for consideration was the covers; and as it had not been thought that reinforced concrete was applicable for this purpose (although the writer now believes that another member of the Institution is considering the idea), the difficulties do not appear as insurmountable. However, only steel was thought of; and, as the area of the lid is 18 ft. by 25 ft., a pressure of 48 in. would give a lifting power of 50 tons on each lid. It was therefore necessary to design a lid which should be both light and strong, and have a curb sufficiently stiff to permit of the fastenings being spaced more widely than is usual with cast-iron purifiers, as it was thought advisable not to have too many lugs in the concrete.

The covers (fig. 2) have a steel channel curb, which is welded at the joints to ensure their being gas tight. The fastenings are a special type of eccentric (fig. 9), in which the fixed pins are held by cast-iron blocks bolted to the channels between the flanges. The hooks engage with steel lugs (fig. 10), which were designed so that they could be put in place and concreted-in without interfering very much with the shuttering. The holes for attaching the fastenings to the channels were drilled *in situ*; and it will be evident from the diagram that the fastenings have also in themselves a fairly wide range of adjustment and accommodation for varying positions of the lugs. It will also be seen from the diagram that the eccentrics will give a good tightening grip at widely varying angles; and the adjusting screw will provide in each case for giving the eccentric its maximum movement.

The method adopted for raising and lifting the covers from the box when the purifying material has to be renewed is a simple form of hydraulic jack on a carriage running on a light railway track. These jacks are indicated in fig. 1. One of the jacks on each side of the cover will raise it by means of a removable bar, which slips into suitable cleats fixed on the cover, and which is provided with a

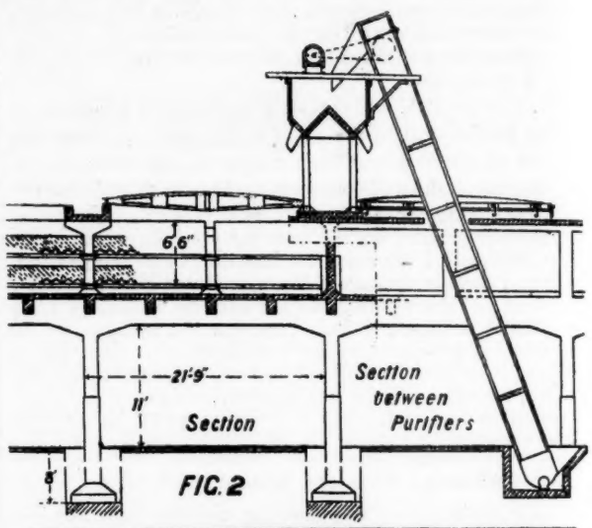
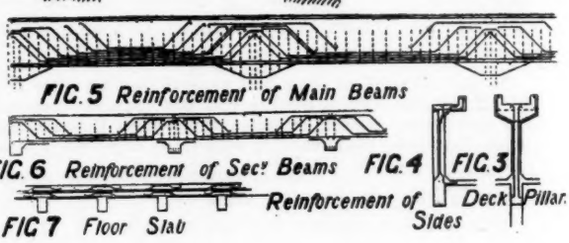


FIG. 2



stirrup-shaped end engaging with the jack. The carriage is fitted with travelling gear. The lid can thus easily be moved on to the top of the corresponding lid of the adjacent purifier, leaving everything clear for the operation of emptying and refilling. For the suggestion of this method, the writer is indebted to Mr. A. A. Johnston, of Brentford.

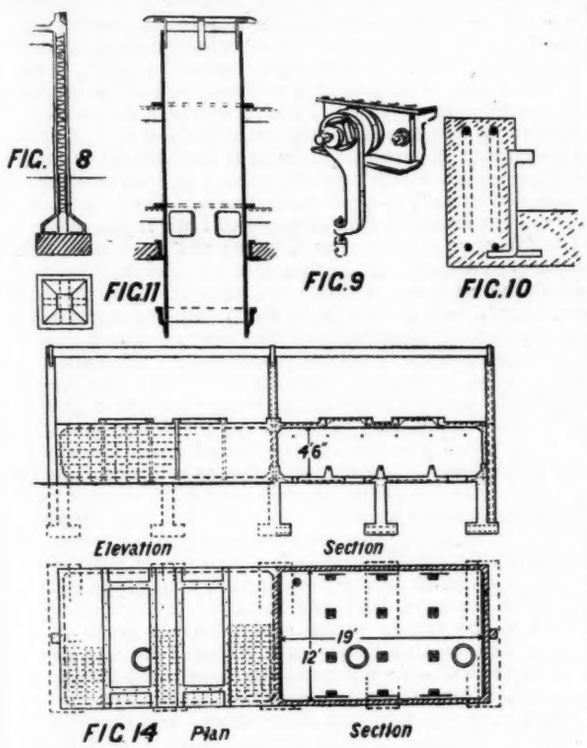
INLET AND OUTLET PIPES.

The next consideration was the attachment of the inlet and outlet pipes. Flanged pipes could easily have been used; but it was thought advisable to prevent the weight of these 24 in. pipes from resting on the floor of the purifiers. A cast-iron socket was therefore designed, somewhat in the form of a gland. This was placed in position on the shuttering and solidly concreted in. On completion of the vessels, these sockets were closed for testing purposes with boards and clay, and 4 ft. of water was run into the purifiers. This represented a heavier load than they would ever carry in ordinary work, and, besides being a test for leaks, ensured the maximum settlement (if any) of the foundations. The inlet and outlet pipes were subsequently passed through the sockets, and the lead joint which corresponds with the packing in a gland allowed the joint to be made without difficulty, and provided for "breathing," or the settlement either of the pipes or the purifiers.

The bottom discharge doors (fig. 12) for the spent oxide had also to be attached to the floor; and a similar casting was used for this purpose. In this case, however, no provision was necessary for movement; and the bottom discharges were made with a flange to correspond with the flange of the socket. It was desirable to ensure a straight and unimpeded fall for the spent oxide; and the lid was therefore designed to be operated by a screw to tighten it against the rubber joint. The whole arrangement was fitted on a running carriage (fig. 12), so as to be moved easily quite clear of the opening.

The grids for carrying the oxide are of a novel design, for which the writer is also indeted to Mr. A. A. Johnston. These are shown in fig. 13, and need no explanation. Certain advantages which belong to them, however, may be briefly enumerated—viz., they are quite easily made by any rough carpenter on the works. They are less susceptible to blocking than the ordinary type, and are easily repaired. It has been found that the span should not be much more than that given to the ordinary type of grids—viz., about 4 ft.—as otherwise they have a tendency to sag and cause short-circuiting.

In fig. 1 these grids and bearers are shown as they would



now be arranged in the light of experience. There are only two layers of oxide in each purifier. In fig. 11 (a section of an inlet pipe) it will be noticed that there are portholes below the bottom layer, while the open end of the pipe is above the top layer. The outlet pipe is taken from between the two layers—thus ensuring the slowest possible travel of the gas through the purifying material, and the reduction of back-pressure to a minimum.

The testing of the purifiers by filling them with 4 ft. of water has already been referred to. There were practically no leaks in the floor under this head of water. It was not possible to fill the purifiers completely, as the weight would have been too great for the stanchions, although it would not have been so for the floor slab and beams, which have to resist the gas pressure as well as the weight of oxide, &c.

Testing the Decks.

The following somewhat novel method of testing the decks was adopted. After the covers had been put on, a dam of clay, about 4 in. high, was made across the end of each gangway, and the whole enclosed area of the concrete was covered with water about 3 in. deep. The exhausters were then set to work, compressing air into the purifiers until a pressure of 36 in. was attained. The presence of leaks would thus be indicated by air-bubbles coming up through the water. Fortunately, the result was a negative one; and the absence of leaks was inferred from the absence of bubbles.

Dealing with the Oxide.

It will doubtless be remembered by those members who visited Tottenham in 1917 that the top of the purifiers was reached by means of a temporary spiral staircase used pending the decision of the best method of handling the oxide. Owing to war conditions, it was decided not to adopt an elaborate scheme, so a permanent staircase was constructed as shown in fig. 1, and a simple arrangement for dealing with the oxide as shown in fig. 2 was installed. It consists of an elevator which discharges the oxide into a concrete hopper on the top deck, from which barrows are filled by gravitation and are then wheeled on movable runways across the openings to the place where it is to be deposited.

The spent oxide, on being discharged from the purifiers, drops through the discharge spouts into the hopper of a disintegrator mounted on a semi-portable carriage. Owing to the height of the purifiers, it has been possible to mount the disintegrator sufficiently high to discharge into barrows. The pulverized material can then be directly wheeled and distributed about the revivifying floor. The sequence of the purifiers is controlled by a Weck valve indicated in fig. 1. This type of valve has been in use on the purifiers erected in 1896. It lends itself to this arrangement of purifiers better than some more modern valves, and experience has shown it gives little trouble.

The success of the Tottenham set of purifiers justified the adoption of the same principle to some new purifiers for cyanide extraction at the Ponders End works. These are shown in fig. 14, and are of much simpler construction—first, because they are much smaller, and, consequently (as the cyanide system requires only one layer of oxide), the decking can be more extensive and the covers (which for cyanide are made of cast iron) smaller in proportion. It will be seen that reinforced concrete has also been utilized for the supports of the runway beam for lifting the covers.

To conclude, it may be remarked generally that reinforced concrete for large purifiers is undoubtedly very economical, and can be made more so if standardized in multiples of even feet dimensions, so as to allow of the use of standard shuttering. Care must, however, be taken in the execution of the work, which should be entrusted only to firms having experience of the essential care which is necessary to the successful carrying out of the designs.

For assistance in the preparation of materials for this paper, as well as for the execution of the diagrams for illustrating it, and for his responsibility for the scientific calculations involved in the construction, the writer has to thank his Chief Assistant, Mr. J. Fisher, Assoc.M.Inst.C.E. (a member of the Institution), for his ready and willing help.

Appendix.

The following details of the reinforcement used may be of interest to the members.

Floor slab, 5 in. thick; 5 ft. 5 in. span; $\frac{7}{16}$ in. dia. rods, 6 in. centres.

Secondary Beams.—14 ft. 3½ in. span. Total depth 21 in. by 10 in. wide.

Reinforcement, one rod 1 in. dia.; two rods $\frac{7}{8}$ in. dia. One rod in the top $\frac{7}{8}$ in. dia.

Main Beams.—Interior, 21 ft. 8½ in. span. Total depth, 33 in.; width, 13 in.

Reinforcement of end spans, four rods 1¼ dia. and four rods 1 in. dia.

Reinforcement of middle spans, three rods 1¼ in. dia.; two rods 1 in. dia.

Two top rods, 1 in. dia. in both. These take part of the negative B.M. over stanchions, and are used for anchoring shear members.

Columns.—Interior 15 in. square; exterior, 13 in. square. Each reinforced with four rods 1⅛ in. dia., bound with ¼ in. wire, 9 in. pitch. Extra rods to form feet.

Sides.—7 in. thick. Reinforced with ½ in. dia. rods 12 in. centres.

Decks.—6 in. thick, cantilevered over 2 ft. reinforced with $\frac{7}{16}$ rods 6 in. centres.

Curbs.—8 in. wide 10 in. deep, reinforced with two rods $\frac{7}{8}$ in. dia. on top, two rods $\frac{7}{8}$ in. dia. in bottom, which also serve as ties across the purifiers.

Deck Pillars.—Centre 10 in. square with four rods 1¼ in. dia. Under gangways, 10 in. square, with four rods 1⅛ in. dia.

Division Wall.—10 in. thick, with ½ in. dia. rods 9 in. centres.

Side Decks.—These, to resist outward pressure of the sides, have three rods 1 in. dia. between the points where they are tied in.

Discussion.

The President: I rise to express our thanks to Mr. Broadberry, who has in this helpful manner stepped into the breach that would otherwise have existed. I had been very much impressed with the concrete coke-bunkers at the Glasgow Corporation Gas-Works, and had spoken to Mr. Alexander Wilson, who had very kindly consented to give a paper on his concrete coke-storing plant. Unfortunately, however, he has been laid aside, and we have had to excuse him for the present; but we are looking forward to the day when he may give us the description. Mr. Broadberry, in place of Mr. Wilson, very kindly undertook to give this paper, for which we thank him very heartily, as well as Mr. Fisher, his Chief Assistant.

Mr. Thomas Goulden (London): I should like to make one or two remarks, not so much for the purpose of discussion, as for conveying to Mr. Broadberry my personal congratulations on his having had the courage to put in the purifiers he has at Tottenham. They seem very admirable, both in construction and working. More particularly do I thank him because he gave an example by which I have been able to profit myself. We had occasion to put down some purifiers during the war; and naturally, in the position then existing, one was driven to concrete—steel and iron being practically out of the question. But, apart from this, I think I should have gone to concrete anyhow. No doubt, it is coming along; and it is thoroughly good. We had had a good deal of experience for coke bunkers, and are putting them in for coal; and in every case the concrete has been admirable, and much cheaper for the same work than iron and steel—particularly at present prices. I have gone one rather better than Mr. Broadberry. My purifiers are in two sections of sixes, 40 ft. square. They are not so large as Mr. Broadberry's, but there are some important features in working that I shall later on be very pleased for the members to see—perhaps during the coming winter. I wish to express my very great indebtedness to Mr. Broadberry for the assistance he unconsciously gave me by his example. He is very much to be complimented on the work he has done, and on the outcome of the boldness with which he approached and dealt with the matter.

The President: I should like to ask one question. I observe a slot in the inlet-pipe, and that you are working two layers of oxide, which caused me some surprise at first. Now I understand that the gas divides itself into two parts, and that each half goes through one layer of oxide. You have therefore in one box both upward and downward purification.

Mr. Broadberry: That is right.

The President: The gas divides itself up in some proportion or other, which is uncontrollable, to go through the layers of oxide. Have you had sufficient experience to tell us anything about the effect of moisture and the distribution of gas through the purifying mass, and the general behaviour of upward and downward purification as exhibited in these boxes, where you have both systems working at the same time?

Mr. W. Newton Booth (Woolwich Arsenal): I had occasion to put in some concrete purifiers quite recently. Like Mr. Goulden, we were forced to concrete, because iron could not be obtained; and like him I am very well satisfied with the result. But I have done something which Mr. Broadberry considered desirable, and that is, before treating the concrete at all to make it non-porous, I tested it. There were five purifiers, 29 ft. by 26 ft. inside, and about 5 ft. 9 in. deep, resting on the ground, which was damp clay, so that one would not get much leakage from the bottom. When we began to test, we found the same trouble as Mr. Broadberry—that is, some of the places where the work was finished off at night and proceeded with next day were weak. The method I adopted was to drill a small number of holes into the porous portion, and pump in thin grout under pressure. This was a very satisfactory solution of the trouble. We found that a purifier of this kind, where the walls had not been treated to make them non-porous, leaked at the rate of about 3 or 4 c.ft. (of air) per minute at a pressure of 30 in. with roughly some 800 square feet of surface; about 1-200th of a cubic foot per minute per square foot of reinforced concrete. This figure might be useful. Four of the boxes were treated with two coats of "Ironite," according to the instructions of the makers. These were perfectly satisfactory; and no leakage was found after the treatment had had time to settle into the concrete. The fifth box, as an experiment, was treated with a solution of water-glass. I put on four coats, very much as whitewashing. That is just as tight as the others, and it has been working twelve months without trouble. As to Mr. Broadberry's manner of treating his gas flow, has he found any trouble? I was faced with very considerable difficulties owing to a rapidly increasing load; and I adopted the method simply because the purifiers would not otherwise pass the amount I had to deal with at the pressures I could afford to give them. It was found necessary to take the very greatest care to ensure that the resistance to the flow of gas in the two layers of oxide was approximately equal; but by taking such care, I managed at length to get a satisfactory splitting of the stream, and so overcame my trouble.

Mr. R. Bruce Anderson (London): My attention was first drawn to concrete construction by our veteran member, Mr. H. E. Jones, who had erected concrete purifiers at the works of the Commercial Gas Company. Shortly afterwards I had to erect some purifiers, and in calculating them out I found I could construct them more cheaply of iron—iron being cheaper in those days—than of concrete. I went to the length of putting in a concrete bottom and having iron sides. By the time I had prepared the moulds and everything that was incidental to the making of concrete for a comparatively small job, I found it was cheaper to simply content myself with a concrete bottom, and have cast-iron sides, which could be done more cheaply. There were some details in connection with them which I might just mention. The covers were made with Z irons; and there were three guide-pins arranged in the flange of the upright sides upon which the cover was to guide into position. Then the cover was simply bolted down by bolts. I had before me at the time several arrangements for the covers; but as we had to use these covers very seldom, there was no necessity to go to any great expense in resorting to any of these complicated schemes of fastening. We have erected a number of purifiers since, and have always fitted the same kind of joint, which you can tighten by bolts, and there is no sign of weakness. Another objection to using concrete for the sides was that, whereas iron would be about 1 in. in thickness, concrete would be 7 in.; and that takes off about 1 ft. from the inside dimensions of your purifier, which is a very valuable consideration. It struck me, in hearing the paper, that Mr. Broadberry might have used his gas outlet and inlet pipes as discharge doors for his oxide. With regard to the raising of the covers, he has given us no details of the method he has used. What I did was simply to have vertical joists alongside the boxes; and the covers were taken up vertically without being traversed at all. Cotters were put in to hold them safely; and they formed a roof for the men to work under. With respect to the inlet and outlet pipes, I used ordinary gas-pipes carried through the ground and brought up through the bottom of the purifier.

Mr. H. Simmonds (Bury): I have found that the bottom layer takes up from 8 to 10 p.ct. more than the top layer. I would like to know whether Mr. Broadberry has made a test, and found that the bottom layer takes up more sulphur than the top?

The President: Have you turned from downward purification altogether?

Mr. Simmonds: Yes.

The President: The question of the space occupied by concrete has been mentioned; and it is certainly one of the things that must be taken into consideration. The advantage of the space you give to concrete is that it stays there, and does not corrode away; whereas if we put in an inch plate of quite good cast-iron it may be that it does not remain an inch. The concrete will not be eroded away in the way that even an inch cast-iron plate is eroded.

Mr. J. H. Brearley (Longwood): I should like to ask for comparative costs—say, in percentages—of the work as carried out on these purifiers, compared with what it would have cost to carry it out in the more customary form of cast-iron sides and wrought-iron covers. Of course, nothing

has been said on the financial side in the paper. But it is an axiom of sound engineering that costs should be considered; and I am quite sure Mr. Broadberry would give us the figures if he can.

Mr. J. FISHER (Tottenham): I hope the President will not call me to order, because I want to thank Mr. Broadberry, not so much for his paper, but for the very kind and generous recognition of my own work at Tottenham. This is not the first time that he has done it; but it is the first occasion on which I have had the opportunity of offering my thanks to him in the presence of the Institution. I think you will all realize that when one's work is appreciated in this manner, it becomes a very great pleasure.

Mr. Broadberry's Reply.

Mr. BROADBERRY: I have to thank all the members who have joined in the discussion, and particularly I want to thank Mr. Goulden for his appreciative remarks. The President raised the question of the effect of moisture and condensation and the flow of gas in the upward and downward system; and Mr. Simmonds asked whether we had made any tests. I very much regret that we have not made any tests. We have not observed any particular difference in the condition of the oxide in the top and bottom layers; but we certainly will be careful to take some tests to ascertain whether the top or the bottom layer is the more active. I do not, however, think we shall find much difference from the appearance of the oxide itself. The faults that I mentioned at the joints were not sufficient to make it necessary to put into practice the plan adopted at Woolwich Arsenal, of forcing grout into the fissures. We have never been able to detect any leakage of gas from these faults. But there is still a slight discoloration coming through; and it is quite possible from this to trace the different stages of the work—where it was stopped and restarted. It is, however, impossible to detect, even by smell, the slightest leakage. I think in all probability the trouble Mr. Booth encountered in working the upward and downward system was from the rapid speed at which he had to force the gas through the purifiers. I regard the arrangement for splitting the streams of gas as particularly advantageous in getting a slow travel of gas through the purifying mass. It leaves a longer time to form contact, and for the chemical action to take place. When the gas is travelling very fast through oxide, there is not the time allowance necessary for the reaction. Mr. Anderson suggested that the inlets and outlets might have been used as bottom dischargers. It had not occurred to me; but I can quite see they could be used in that way. On the other hand, our box is provided with four bottom dischargers; and if we had used both inlet and outlet pipes, we should have had two bottom dischargers for each purifier, whereas we provide four. Others would have been necessary. Mr. Brearley raised the question of cost. I really anticipated that a question of this sort might be asked; and therefore I reserved the information that since the paper was prepared we have decided upon a further set of reinforced concrete purifiers for our Ponders End works. Those mentioned were for cyanide extraction purposes; but since then we have arranged to put in a set for gas purification. They will be five in number, and each will measure 38 ft. by 20 ft. by 6 ft. deep. The contract price for the cast-iron stanchions, the foundations, beams, and concrete portion of the body of the purifiers amounts to £3320. This works out at 2s. 3½d. per cubic foot of purifier space. We have estimated very carefully what cast-iron stanchions, steel framework, and cast-iron boxes would have cost; and we make it £6420, or just about twice what the job will cost in reinforced concrete. That, of course, is at present high prices both for concrete and cast iron. The cost of the concrete he had mentioned—2s. 3½d. per cubic foot—was more than it was in the case of the Tottenham purifiers, which were put in some three years ago. The cost for them worked out at 1s. 6½d. per cubic foot. Added to this must, of course, in either case be the cost of the steel lids. But making the comparison between cast iron and concrete purifier bodies, you may take it that cast iron, whether calculating on pre-war prices or present prices, comes to about 100 p.ct. more than the reinforced concrete.

The PRESIDENT: I hope, Mr. Broadberry, you will take the applause which has been accorded you as a sign of our great appreciation of your paper.

War Experiences of British Gas-Works.

The PRESIDENT: Our friend, Mr. H. Townsend suggested to the Council through me that it would be a good thing to have a record of the extraordinary damage done to gas-works during the war; and we believe that information is being gathered together on the Continent on the same subject. We quite appreciated Mr. Townsend's suggestion, and decided to ask him to get together the information in this country, not as a punishment for having suggested it, but because he had already put his heart into the matter. Mr. Townsend has really done the work in a most helpful manner.

Mr. H. TOWNSEND (Wakefield) then submitted a lengthy paper detailing "Some War Experiences of British Gas Undertakings." There was not time enough to allow of his reading it; and he consequently confined himself to throwing on the screen and explaining an excellent series of photographic slides which he had had prepared to illustrate the paper. The main portions of Mr. Townsend's communication will be found on pp. 624-33. With regard to the photographs, a number of these have already appeared in the pages of the "JOURNAL."

The PRESIDENT: I am sure we highly appreciate the skilful way in which Mr. Townsend has responded to our request to exhibit his slides, and that you are quite convinced of the value of his paper. We desire to thank Mr. Townsend for his work, and the gentlemen who have communicated information to him. On the point of the suction effect that takes place in the case of some chemical explosions, this is confirmed by my experience at St. Helens. There we had many years ago a very powerful explosion of chlorate of potash; and the glass in every instance was sucked out into the street. It is really most remarkable, but it is a fact.

Mr. TOWNSEND: Thank you very much. The preparation of the paper has been a labour of love.

New Honorary Members.

The PRESIDENT: I move that the following gentlemen be elected to the position of honorary members of the Institution.

The President of the French Society.
The President of the Italian Society.
The President of the American Gas Association.

Mr. C. E. JONES (London): In seconding that, I should like to say, if you will allow me, that, as we have furnished one of the most important services to the people of this country and Europe in general during the year—on the sea, in the air, and on the earth—it will be a graceful thing on the part of the Council to select a few of the gentlemen who have distinguished themselves in the paths of warfare I have indicated, and make them honorary members of the Institution.

The resolution was unanimously agreed to.

Place of Next Meeting.

The PRESIDENT: With regard to the time and place of the next meeting, will you leave it to the Council as to where it should be? You have elected Sir Dugald Clerk to be my successor; and we should like to know his wishes. I take it that you will agree to leave to Sir Dugald Clerk and the Council the place of the next meeting. I think it would meet with your approval if it were in London. [The members indicated assent.]

Votes of Thanks.

Mr. JAMES PATERSON (Cheltenham): I rise with the expressed consent of the President, so I hope he will agree with what I have to say. I have had put in my hands what I think is one of the most important matters that take place at the close of this meeting. I have to propose that our heartiest thanks be given to the President, Mr. Samuel Glover, for all he has done for us during the past year, particularly in the conduct of the proceedings at our meetings this week. I do not know what words I can use to indicate what I feel in this connection. Mr. Glover has put in, as some of us know, a tremendous amount of time in the interests of the Institution. He has secured during this last

year a consummation of our hopes and desires in the report that Sir Dugald Clerk and his colleagues have produced, and which is now going forward for consideration in the proper quarters. I think that it is our duty—certainly, it is our privilege and pleasure—to offer our heartiest thanks to Mr. Glover for all he has done. I should like to mention one particular phase of the kindness he has extended to us, by referring to the hospitality he, with Mrs. Glover, showed to us on Tuesday evening. A more enjoyable function I do not remember having attended; and I am sure those who were there will share with me in feelings of gratitude and thanks to Mr. and Mrs. Glover.

Mr. R. BRUCE ANDERSON (London): I rise with much pleasure to second the vote of thanks so eloquently proposed. The President has been doing noble work outside the Institution as well as in it; and the way in which the proceedings of this meeting have been conducted is indicative of the way the work generally that he had been engaged upon has been put through. Our condition would have been much worse but for the work he has done on our behalf.

The PRESIDENT (who was received with prolonged applause) said: Gentlemen, you have not embarrassed me. Thank you very much, Mr. Paterson, for what you have said, and you members who have been sympathetic towards the way in which we have been going on. To hear you say that you are appreciative of what has been done during the year is very gratifying to me indeed. The work has been of a congenial character to me, because of the absolute loyalty and helpfulness of everybody with whom I have come in contact. Everybody whom I have asked to do anything has done it to the best of his ability, and with great heartiness. The work has been of a most interesting character, also, all through the year; and the Council have felt the importance of the occasion. So far as I have done what you expected should have been done, so far as I have interpreted your wishes and done your work, the measure of gratification that comes to me is just the measure of the degree in which I have served you. What I have done is just an example of what I could do if I had the place of power and the staff. I have had a big staff, and I have had a big task; and the fact that it has been performed in some degree to your satisfaction is very gratifying to me. With regard to the pleasurable part of it, I shall convey to Mrs. Glover your message of appreciation, and also to my son and daughter who provided part of the programme. In all that, we have had the assistance of each member of my family, because I have here been too busy on more material things to have much to say or do in the matter.

Mr. H. POOLEY (Leicester): I rise to propose a vote of thanks to the Council and the Hon. Secretary. The work of the Council is most difficult and most onerous for country members. It may not be quite so onerous for those in town; but at the same time it always has been difficult. I think the attendance at these meetings shows the sustained interest which has been kept up in the proceedings this year; and it must be very gratifying to the Council themselves for their efforts. I think I need say nothing about Mr. Price's work. We all know what it has been; and we thank him most heartily. It is a great pleasure to me, an old member of Council, to propose this vote of thanks.

Mr. L. J. LANGFORD (Tunbridge Wells): I have very great pleasure in seconding the vote.

The PRESIDENT: I rise to support the vote. The Council have been very helpful to the President, and to the whole of the work of the Institution; and you cannot do better than express most heartily your thanks to them for the work they have done for you.

The vote of thanks was heartily accorded.

Mr. THOMAS GOULDEN (London): Allow me to thank the proposer and seconder of this resolution in the most hearty way that I have at my disposal. Also let me thank you, Mr. President, for the commendation that you added to the kind words of Mr. Pooley and Mr. Langford. The Council thoroughly have their hearts in their profession; and it requires no more than that for any gentleman present, if he were on the Council to do the same.

Mr. W. E. PRICE, also replying to the vote, said: Mr. President, I thank the meeting for the very cordial way in which they have received the portion of the resolution which referred to me. While I have done what I could, as your President said, he has done what he could; and I would like to say a word in praise of the Council, and those others whom I have had more or less to guide from time to time. I have had a very pleasant year with Mr. Glover; and I am very sorry that the year has come to an end—rather that the two years have come to an end, because Mr. Glover has been practically President for two years, which to a great extent accounts for the success and the high position he has attained, because he has had double the time of training that most Presidents have.

The PRESIDENT: I rise to do a duty which I am sure you would feel was a neglect if we did not perform, and that is to offer an expression of our pleasure at seeing Mr. Dunn here to-day, restored to health and strength compared with what he was at one time during the year, and to thank him for all his services to the Institution during my term of office. Perhaps Mr. Dunn might consider that I am a bit of a driver; but he has responded to the reins, and did not need the whip. I thank him personally for all he has done for me, and for his careful handling of every detail that I have had to call attention to.

Mr. W. E. PRICE: May I be allowed to second that, because I feel a personal pleasure in doing so. I have seen the work that Mr. Dunn has performed; and he has been a wonderful help in many ways. I am very sorry that he had to go away for a time; but I am pleased to see he has come back entirely restored to health.

The vote of thanks was cordially passed.

Mr. DUNN: It is a very difficult thing for me to express what I feel. I want to thank the Hon. Secretary and the Council for the consideration they showed me during the period of my enforced absence. I was exceedingly sorry to have to go away under doctor's orders. I have experienced nothing but kindness at your hands and those of the Council. There is a lot of work to do; and you may rely upon my doing what has to be done to the best of my ability.

Mr. E. G. SMITHARD (King's Lynn): I propose a hearty vote of thanks to the Research Committees, Scrutineers, and Auditors.

Mr. H. WIMHURST (Sleaford): I rise to second the vote of thanks for the services these gentlemen have rendered.

Dr. E. W. SMITH (Birmingham): All I can do is to acknowledge with great gratitude the thanks of this meeting for the work the Research Committees have done. We have been called upon to do it. It is not a soft job to be on the Research Committees; but it is part of our duty to the Institution to carry it out. We are delighted to serve you, and shall continue to do so as long as you desire it.

The PRESIDENT: I move that our best thanks be given to the Institution of Civil Engineers for the use of their hall, and for the facilities extended to us during the meetings. The Institution of Civil Engineers lent us their hall with the greatest heartiness; and all the time we are making use of it they extend to us all sorts of attentions.

Mr. J. W. AUCHTERLONIE (Cambridge): I have very great pleasure in seconding the vote. This building is not only beautiful, but it is commodious.

Mr. CHARLES WOOD (Bradford) supported the vote, which was unanimously passed.

The PRESIDENT: The subjects that have been named on the question papers were not quite so numerous as I thought they would have been. This is of very great satisfaction to the Council, because it shows that there are not very many disgruntled members of the Institution of Gas Engineers. The bulk of the questions reveal that it is desirable to give members who so wish the opportunity of meeting and conferring together on subjects that they are interested in, which cannot be discussed at these meetings. Such a meeting is that which will be held this afternoon, to deal with the question of status and salaries of gas managers. Any questions that cannot be discussed then will be answered in the "Transactions," where answer is still called for. That completes the business.

HIGHER MAKES

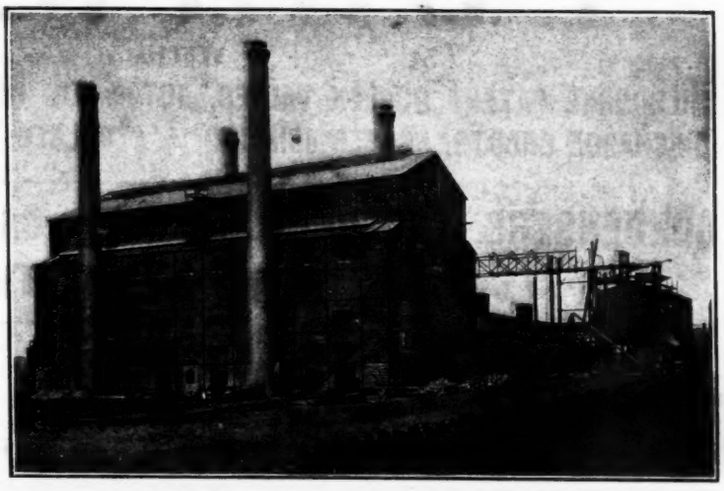
WITH **LESS FUEL** &

LOWER LABOUR COSTS

SHOW REAL

ECONOMY.

THEREFORE INSTALL THE



WOODALL-DUCKHAM SYSTEM OF CONTINUOUS CARBONIZATION

FOR PARTICULARS APPLY :- THE WOODALL-DUCKHAM Co. Ld.
231 STRAND. W.C.2.

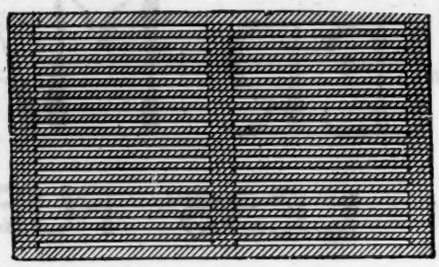
J. HAWLEY & SONS,

Tel. Address: "HAWLEY, PENISTONE." **Grid Works, PENISTONE.** Telephone: No. 17.

MANUFACTURERS OF

Wood Sieves for Gas Purifiers.

The Original Makers of Wood Grids with Square Iron Bolts.



Hurdle Grids for Deep Filling.

Board Filling in Sections for Scrubbers.

ESTABLISHED 1820.

GASHOLDERS

MILBOURNE PATENT ROLLER CARRIAGES. AUTOMATIC LUBRICATION.

PURIFIERS

WITH

MILBOURNE PATENT DUPLEX VALVES, AUTOMATIC COVER FASTENERS, SAFETY DISCHARGE SHOOTS, RUBBER JOINTING. "MILBEL" PATENT PURIFIER GRIDS.

CONDENSERS, SCRUBBERS, AND GAS WORKS PLANT OF EVERY DESCRIPTION.

C. & W. WALKER, LTD., DONNINGTON, NEWPORT—SALOP.

LONDON OFFICE: 110, CANNON STREET, E.C.

WATER GAS PLANT.

ECONOMICAL GAS APPARATUS CONSTRUCTION COMPANY, LIMITED,

36, Victoria Street, London, S.W.

GAS INVESTIGATION COMMITTEE.

Second Report of the Research Sub-Committee appointed by the Gas Investigation Committee of the Institution of Gas Engineers; adopted by the Gas Investigation Committee, May 1, 1919.

The Gas Heating, Lighting, and Ventilation Research Committee of the Institution of Gas Engineers and the University of Leeds has continued to act as the Research Sub-Committee of the Gas Investigation Committee "for the purpose of investigating the relative efficiencies in use of different grades and compositions of gas," and for the further purpose of investigating comparative economies in production.

The composition of the Research Sub-Committee is given below:

Chairman.—Professor Arthur Smithells, C.M.G., F.R.S.

Representatives of the University of Leeds.—Professor J. B. Cohen, F.R.S., Professor John W. Cobb, C.B.E., B.Sc., F.I.C. (Hon. Secretary), and Mr. G. R. Thompson, B.Sc.

Representatives of the Institution of Gas Engineers.—Messrs. John Bond, O.B.E., J. H. Brearley, E. W. Smith, D.Sc., F.I.C., and Chas. Wood, F.C.S.

Mr. Lawrence Hislop, F.C.S., was co-opted a member of the Research Sub-Committee for the purpose of research work at Uddingston.

Mr. James W. Wood, M.Sc., A.I.C., has continued to act as Research Chemist for carrying out the inquiry into the relative efficiencies in use of different grades of gas, and Mr. A. Parker, D.Sc., A.I.C., has been appointed for the purpose of investigating the comparative economies of production, under the supervision of the Livesey Professor, J. W. Cobb. Two Research Assistants have also been appointed, Mr. H. Kerr, Diploma Fuel and Metallurgy, Leeds, and Mr. F. S. Townend, B.Sc. (Lond.).

The first report of this Committee dealt with the results obtained in initiating a systematic survey of the relative efficiency in use of different grades of gas. Such a survey demanded a large number of experiments to be made with many gases, in the first place on existing appliances without modifications, to be followed by other experiments made with appliances modified to meet the varied requirements of different grades of gas. Work is being continued on these lines, and further results so obtained are reported below. A special need of the nation and the industry at this time has, however, asserted itself emphatically and caused the inquiry to be pushed forward in one particular direction with the object of obtaining badly needed information. The importance of coal conservation is receiving general recognition, and although the gas industry stands in a particularly strong position with respect to it (since the thermal efficiency of the carbonization process is from 70 to 80 p.ct.) no opportunity of further possible economy should be missed. The calling into council by the Board of Trade of Sir George Beilby and the Fuel Research Board should ensure that any new legal standards adopted for public gas supply will not stand in the way of developments which tend to the further conservation of fuel but will encourage them. The most direct line of progress for the gas industry is to secure a higher percentage of the heat of the coal in the gas, because no other form of fuel is capable of the same high degree of efficiency in all-round use. Gasification of the coke as water-gas inside the retort or in separate generators is a simple means to this end. If blue-water-gas is made separately, no more is demanded than an extension of what is already practised in many gas-works, with the modification, which is really a simplification, that carburetting is not essential. If water-gas is made in the retort by steaming, the process is one which has already been worked to some extent, but is not general practice. It has possibilities outside the interaction of steam and carbon to form water-gas, since the influence of an ascending gas on the descending charge and its products of decomposition in the retort is undoubtedly of importance in other ways as affecting the quantity and quality of all volatile products, including motor spirit, fuel oil, and ammonia. Gases other than steam have also to be considered in this connection.

It will, therefore, be understood that we have welcomed the opportunity afforded by Mr. Lawrence Hislop and the Uddingston Gas Company in placing their installation of continuous vertical retorts at our disposal for the purpose of investigating the mode of manufacture just described, which Mr. Hislop has been practising for some time past. Dr. Parker as Research Chemist, went to the Uddingston works at the beginning of February, and has been going through the necessary preparatory work since that time and has now started tests. The results may be expected to place in our hands very soon definite and quantitative information on the working of this development of gas practice—a thermal and chemical balance-sheet of the process—of a kind which should prove of a high degree of usefulness and of a completeness which has hitherto been lacking. It is plain, however, that the efficiency of this or any other process of production is dependent upon the efficiency of utilization of the product. The position with reference to the steaming process or to the blue-water-gas process, as providing the possibility of increasing the percentage of the total heat energy of the coal carried by the gas, is that in either case the calorific power of the gas per cubic foot will be diminished. It was, therefore, of primary importance to make direct tests on the gas at Uddingston, deliberately made of a lower calorific value than that in common use today in order to determine whether such gas when made was satisfactory and economical in use. It was realized too that information on this point was wanted quickly, and therefore a special position in this investigation was accorded to it. Minor modifications in appliances, such as could be carried out quite readily and quickly, were made as required.

Mr. James W. Wood, Research Chemist, went to Uddingston and tests on the gas were made for both high and low temperature uses. The incandescent mantle burner was taken as the appliance with most stringent requirements for high-temperature domestic use and the ring burner as representative for low-temperature use; both these appliances being tested in our more general survey, comparison with results already obtained with other gases were assured.

The results indicated that gas of the grade tested at Uddingston (approximately 400 B.Th.U. gross per c.ft.) could be used with a good efficiency in both low and high temperature appliances, when the simplest possible modification of the burners tested was made by enlarging their nipple orifices. Details of the tests at Uddingston and Birmingham are reported below.

The Committee would like to acknowledge its indebtedness to the Birmingham Corporation Gas Department and the Uddingston Gas Company for the facilities they have afforded, and to Mr. James W. Wood, Research Chemist, for his continued exercise of care and skill.

Report upon the Results of Tests carried out at the Uddingston Gas-Works using Gas of Approximately 400 B.Th.U. gross per Cubic Foot.

As indicated in the introduction, the scheme adopted for the systematic testing of the efficiency in use of different grades of gas was departed from, in order to obtain data with regard to the performance of gases of relatively low calorific value as soon as possible, of which a sufficient number should be strictly comparable with those already put forward by the Committee for gases of higher calorific value. This has modified the course of the tests, in that a greater number of burners has been tested using this grade of gas. The departure is justified by the lack of authentic data concerning such gases, and the urgency of the situation as regards proposed legislation for the regulation of gas quality for public supply.

The tests were made by Mr. James W. Wood, M.Sc., Research Chemist, at the Uddingston Gas-Works, where Dr. Parker, also Research Chemist to the Gas Investigation Committee, is conducting an investigation into the question of efficiency of gas production, as distinct from that of gas utilization, so far reported upon.

The gas used in the tests was made by steaming continuous vertical retorts, and was washed for benzol recovery before testing. Such gas has been regularly distributed in the district, and represents a yield of 30,000 c.ft. per ton of Lanarkshire coal carbonized. Throughout the tests the composition and calorific value of the gas have been steady

(385 to 394 B.Th.U. gross per cubic foot) and a single typical analysis will therefore suffice.

Composition of Gas.

CO_2	..	6·1 p.ct.			
O_2	..	0·3			
HC	..	1·0 ,,	CO_2	..	6·1 p.ct.
CO	..	23·9 ,,	O_2	..	0·3 ,,
H_2	..	50·1 ,,	N_2	..	6·4 ,,
CH_4	..	12·2 ,,			
N_2	..	6·4 ,,	Total Inerts		12·8
		100·0			

In uniformity with the earlier report the following additional information is given:

Calorific Value of Gas.

388 B.T.U. gross per cubic foot at 60° F. 30 in. wet
345 B.T.U. net ,, ,, at 60° F. 30 in. wet

Ratio gross : Net = 1·124
Specific gravity . . 0·500
Volume of air required per cubic foot of gas . . . . . 3·1 c.ft.
Volume of self-combustible mixture per cubic foot of gas . . . . . 4·1 c.ft.
B.T.U. per cubic foot self-combustible mixture . . . . . 94·6 B.T.U. groes
86 5 B.T.U. net
Volume of products of combustion per cubic foot of gas (total) . . . . . 3·8 c.ft.
Volume of products of combustion (water condensed) . . . . . 3·0 c.ft.
∴ B.T.U. net per cubic foot of products of combustion $= \frac{345}{3·8} =$ . . . . . 91 o B.T.U.
Ratio total inerts/total products of combustion $= \frac{12·8}{3\,8} =$ . . . . . 3·4 p·ct.

When compared with other gases of the first report, it will be noted that although the calorific value of the gas is low, the air requirements are correspondingly low, and therefore the B.Th.U. per cubic foot of products of combustion are practically unaltered.

Ring Burner Tests.

These tests were made with the same burners and with precisely the same apparatus as was employed for the tests previously carried out at Birmingham. Full descriptions, both of apparatus and methods of working will be found in the first report of the Gas Investigation Committee.

Modifications to Burners.

Without exception, the original appliances gave trouble with lighting-back and with inability to deliver heat units at an adequate speed, when using gas of 400 B.Th.U. gross per cubic foot. The only modification made consisted in broaching-out the nipples and countersinking their outlets so as to give a divergent orifice. (See Fig. 16—A.) This was done by trial until well-aerated flames with distinct inner cones were obtained, but with freedom from lighting-back difficulties. The enlargement was continued so long as it seemed advantageous to do so. No air-slides were used for reducing primary aeration; but the flames could be turned quite low without lighting-back. Other conditions were adjusted when necessary to obtain the best performance from the burner, as judged by experience. The results are expressed in Table XXII.

Tests Nos. 1 and 2.

These were made with the "No. 1 Burner" described in the first report of the Gas Investigation Committee. The nipple was altered to the extent indicated:

Original nipple = 0·0988 in. dia. = 0·0077 sq. in.
Altered ,, = 0·148 ,, = 0·0170 ,,
Relative areas of cross-section $= \frac{170}{77} = \frac{2·21}{1}$

Tests Nos. 3, 4, and 5.

These were made with the "No. 2 Burner" of the first report of the Gas Investigation Committee, which with gases of 500 B.Th.U. gross and upwards had been found rather more efficient than the "No. 1 Burner" used for Tests Nos. 1 and 2.

Original nipple = 0·105 in. dia. = 0·0087 sq in.
Altered ,, = 0·145 ,, = 0·0165 ,,
Relative areas of cross-section $= \frac{165}{87} = \frac{1·9}{1}$

The primary aeration of the modified burner was good, the nipple orifice being opened-out to full bore of the body; a nipple of even larger diameter might have been used.

After the first test with this burner it was found advisable to raise the vessel to 1·75 inches above the burner, to attain satisfactory working conditions.

There is no marked difference in efficiency between burners Nos. 1 and 2, with this grade of gas.

It will be seen that the thermal efficiency attained in the above tests lies between 56 and 60 p.ct. of the net calorific value. The average figure for all grades of gas, given in the first report of the Gas Investigation Committee is 56 p.ct. for Burner No. 1 and about 60 p.ct. for Burner No. 2.

It may therefore be taken that the conclusions with regard to thermal efficiency given (First Report) are confirmed, and that the same thermal efficiency can be obtained with Uddingston gas as with the gases of other calorific values previously tested.

Cooker Hot-Plate Tests.

It was considered advisable to carry out a number of tests with appliances exactly as used by the domestic consumer; and those modified for local use at Uddingston, by opening-out the nipple orifices, were employed.

Tests Nos. 6, 7, and 8.

These were carried out with a typical boiling ring of fairly large size, surmounted by a cast-iron grid or platform for supporting vessels.

The alteration of the nipple is indicated by:

Original nipple = 0·124 in. dia. = 0·0121 sq. in.
Modified ,, = 0·162 ,, = 0·0206 ,,
Relative areas $\frac{206}{121} = \frac{1·7}{1}$

The aeration is very satisfactory, and but for interference by the grid, the flame-contact would be good.

The 1 gallon copper kettle was used for the tests.

The average thermal efficiency obtained, of 41 to 42 p.ct., on the net calorific value agrees very well with the values obtained by us at Birmingham for similar appliances working with gases of much higher calorific values.

Tests Nos. 9, 10, 11, and 12.

These tests were carried out on a small hot plate by a well-known maker.

In tests Nos. 9 and 10 a 1 gallon copper kettle was used, and in Tests Nos. 11 and 12 a 1 quart tinned-iron kettle.

Altered nipple = 0·152 in. dia. = 0·0177 sq. in.

Further opening of the nipple reduces primary aeration too greatly.

Table XXII.

Test No.	Calorific Value. Gross.	Calorific Value. Nett.	Specific Gravity.	Cu. Ft. Gas supplied per Hour.	Equivalent Cu. Ft. 500/450 Gas.	B.Th.U. nett per Hour supplied.	Efficiency per cent. on nett C.V.	Height above Burner. Inches.	Nipple Press. Tenths Water Gauge.	*1 Quart Water Heated 60° to 212° Fahr. requires B.Th.U. nett.	C. Ft. Gas.	Time Mins.
1	385	347	·500	32.8	25.2	11,370	56.2	1.25	20	676	1.9	3.6
2	,,	,,	,,	26.4	20.4	9,166	59.0	1.25	15	644	1.8	4.2
3	,,	,,	,,	29.7	23.0	10,305	58.5	1.25	20	650	1.9	3.8
4	,,	,,	,,	29.7	23.0	10,305	57.5	1.75	20	661	1.9	3.8
5	,,	,,	,,	23.7	18.3	8,288	60.0	1.75	14	633	1.8	4.6

* A 1-gallon copper kettle containing 8 lbs. water was used; the quantitites for 1-quart water being calculated from the results so obtained, as in previous tests.

Tests Nos. 13 *and* 14.

These tests were made with a similar hot plate by a different maker.

The ring burner was rather smaller than above.

The alteration to the nipple is indicated by:

Original nipple = 0·102 in. dia. = 0·0080 sq. in.
Altered ,, = 0·134 ,, = 0·0141 ,,

$$\text{Relative areas} = \frac{141}{80} = \frac{1{\cdot}76}{1}$$

Further opening of the nipple orifice was not advisable.

There are no results in the first report of the Gas Investigation Committee with which those given in Table XXIII. are strictly comparable. It is not intended here to draw attention to the differences between the efficiencies given in Table XXII. and Table XXIII. respectively, since such matters will be discussed in a subsequent report. The essential point for our immediate purpose is that the thermal efficiencies given in Table XXIII. are in close agreement with those obtained by us at Birmingham also using consumer's appliances, but with gases of much higher calorific values.

Summary for Ring-Burners.

1. Ring-burners designed for gas of 500 B.Th.U. gross per cubic foot and upwards give trouble with lighting-back, and with inability to deliver heat units at a satisfactory rate when used with gas of 400 B.Th.U. gross, as supplied at Uddingston; but both difficulties can be overcome by the simple process of opening-out the nipple orifices to a suitable size and shape.

2. Pressures at the burners above the normal are not required to work them satisfactorily and lower pressures are permissible.

3. This gas, of 400 B.Th.U. gross per cubic foot gave as good a thermal efficiency as any other grade with which we have experimented, when used with a suitable modification of the burner, which can be easily made.

4. It follows from the above that the gas of lower calorific value is not so good, foot for foot, as gas of a higher calorific value, but that the value in this use of different gases is directly proportional to the potential heat units they carry. This is in accordance with the results already published in the first report of the Gas Investigation Committee.

5. It would appear from comparison of the Birmingham and the Uddingston results, that probably on account of the composition and mode of combustion of the Uddingston gas, a given burner may be worked at rather a greater B.Th.U. rate on the gas of lower calorific value than on the higher, without loss of thermal efficiency. The flames are rather shorter and do not smother so readily.

6. There are no unusual difficulties in manipulating burners with this gas; and the larger nipple orifices and less sensitive injectors required should reduce troubles connected with corrosion, stoppages, and necessary adjustment.

These results obtained with and reported for ring-burners are obviously directly applicable to all other burners for low-temperature use in which the same principles of construction are adopted.

Incandescent Burner Tests.

Low-Pressure Upright Burners.

These tests on lighting were made as involving the most stringent requirements of high-temperature domestic use.

The apparatus and methods of testing were exactly the same as those of the first report. A 60-in. bar photometer was used with a 10-candle power pentane standard lamp; the candle power quoted being that in a horizontal direction through the centre of the mantle—the maximum candle power. The thermal efficiency in the case of lighting cannot be expressed as a simple percentage, but is expressed as before as B.Th.U. net required per candle power per hour. In addition, a modified reciprocal of the above value is used—namely, candle power per 1000 B.Th.U. net; the multiplication by 1000 being made to obtain numbers of a convenient magnitude. It should be noted that an increase in this value implies a corresponding increase in the thermal efficiency of light production.

As with ring-burners, such initial difficulties as might be expected arose with regard to the pressures required to deliver heat units at a suitable rate and to secure a satisfactory degree of primary aeration; but these were eliminated satisfactorily by the simple process of opening-out the nipples. Three typical burners were tested.

Burner No. 3.—This burner is of very simple construction and is almost identical in design and dimensions with the burner, described as the "No. 1" incandescent burner, in the first report of the Gas Investigation Committee. The refractory head of the burner is pierced with two concentric circles of holes, three thirty-seconds of an inch in diameter, instead of with slots. The nipple contains three orifices of fixed diameter, which were broached-out until satisfactory results were obtained by trial, the increase in area reached being approximately 50 p.ct. The results are expressed in Table XXIV. and fig. 1.

The mantle can be properly filled with flame at suitable gas consumption, the light is perfectly steady, and with the enlarged nipple orifices there is neither trouble with lighting-back nor with undue sensitiveness to air-slide adjustments. As noted in the earlier report, there is a point of maximum thermal efficiency (in this case at 65-candle power) beyond which the illuminating power may be increased, but at the expense of efficiency.

The gas consumption was pushed to considerable excess without attaining a true maximum illuminating power, such as was obtained with certain gases of higher calorific value and greater air requirements per cubic foot of gas.

It will be noted that with the alterations made to the burner, a pressure of 16-10ths of an inch would allow the maximum efficiency to be attained, while 20-10ths of an inch would allow 70-candle power to be reached. Greater pressures than this would seem to be quite unnecessary.

Greater pressures than 20-10ths will be found in the table, in the case of the higher gas consumptions. If for any reason it should be deemed advisable to work at such gas consumptions, the nipple orifices could be opened-out still further without impairing the thermal efficiency with the grade of gas, and at the same time reducing the pressures required.

The maximum thermal efficiency is seen to be 29·3 B.Th.U. net per candle-hour (=34·1-candle power per 1000

Table XXIII.

Test No.	Calorific Value. Gross.	Calorific Value. Nett	Specific Gravity.	Cu. Ft. Gas supplied per Hour.	Equivalent Cu. Ft. 500–450 Gas.	B.Th.U. nett per Hour supplied.	Efficiency per cent. on nett C. V.	Height above Burner. Inches.	Nipple Press. Tenths Water Gauge.	*1 Quart Water Heated 60–212° F. requires: B.Th.U. nett.	Cu. Ft. Gas.	Time. Mins.
6	390	351	·497	39.0	30.4	13,680	41.7	1.88	15	912	2.6	4.0
7	,,	,,	,,	43.7	34.2	15,350	42.4	1.88	20	898	2.6	3.5
8	,,	,,	,,	30.6	23.7	10,660	41.3	1.88	10	921	2.6	5.2
9	394	353	·497	28.7	22.5	10.125	46.8	1.5	25	814	2.3	4.8
10	,,	,,	,,	24.4	19.2	8,614	48.7	1.5	19	780	2.2	5.4
11	,,	,,	,,	24.2	19.0	8,530	34.3	1.5	19	1110	3.2	7.8*
12	,,	,,	,,	24.2	19.0	8,530	33.4	1.5	19	1140	3.3	8.0*
13	,,	,,	,,	19.2	15.1	6,784	49.1	1.5	20	775	2.2	6.8
14	,,	,,	,,	19.2	15.1	6,774	33.8	1.5	20	1123	3.2	10.0*

* A 1-gallon copper kettle containing 8 lbs. of water was used; the quantities for 1 quart of water being calculated from the results so obtained. The results marked * were obtained by the direct use of a 1-quart tinned iron kettle.

B.Th.U. net). This is distinctly better than any efficiency quoted in the first report, in which the best value (Table XVI.) given is 33 B.Th.U. net per candle-hour (=30·3-candle power per 1000 B.Th.U. net).

Our extended experiments with a number of burners have, however, indicated that although the comparative results obtained with the single test burner used in our first experiments (first report) are reliable and the conclusions therein valid, the number, 33 B.Th.U. net per candle-power hour, obtained under the simplest possible conditions and without the use of a chimney can be readily improved upon (see Table XL. of this report). For the purpose of the comparison we are now making, from 24 to 25 B.Th.U. net per candle-power-hour should be taken as the best we have obtained.

It has been found possible to obtain with gas of higher calorific value a higher maximum candle power than those just reported for a gas of lower calorific value, but only with a degree of care in the choice and adjustment of the burner which cannot be regarded as generally exercisable.

This point is raised again at a later stage in the present report.

It has been known for many years that the use of a chimney improves the performance of the upright incandescent mantle. Since the introduction of stronger mantles there has been a tendency to discard chimneys and so reduce maintenance costs. It was a matter of interest therefore to see whether the use of a chimney exerts an effect in the case of gases of this calorific value, comparable with that which it is known to exert in the case of gases of higher calorific value and higher illuminating power. The results of tests without a chimney are given in Table XXIVA., all other conditions being the same as for those in Table XXIVA.

TABLE XXIV.

Burner No. 3—

Original dia. of orifices = 0·028 in. = 0·000616 sq. in. (each).
Altered " " = 0·034 in. = 0·000908 sq. in. (each).

$$\text{Relative areas} = \frac{908}{616} = \frac{1{\cdot}47}{1}$$

Mantle—Glasmi XXX., size C.

Chimney—Plain cylindrical 6 in. × 1⅛ in.

Calorific Value of Gas { 385 B.T.U. gross per c.ft. / 347 " net " } at 60° Fahr. and 30 in. wet.

Specific Gravity—0·500.

Analysis of Gas—The analysis given on p. 6 may be taken to represent the composition of the gas.

No 3 Burner. C Mantle. Plain Chimney.

B.Th.U. nett. per Hour supplied.	C.Ft. Gas supplied per Hour.	Candle Power.	Candles per C.Ft.	B.Th.U. nett. per Candle Hour.	Candle Power per 1,000 B.Th.U. nett.	Press. Tenths Water Gauge.	Remarks.
1300	3.74	23.5	6.30	55.1	18.1	9.0	Air ports quite closed.
1400	4.04	31.2	7.72	45.0	22.2	10.0	
1500	4.32	40.0	9.30	37.4	26.7	11.0	About ½ mantle heated.
1600	4.62	48.0	10.40	33.4	29.9	12.4	
1700	4.90	56.0	11.41	30.4	32.9	13.5	
1800	5.18	61.0	11.77	29.5	33.9	15.0	
*1900	5.48	65.0	11.85	29.3	34.1	16.0	About ¾ mantle heated. Air ports ½ open.
2000	5.77	67.4	11.70	29.6	33.8	17.7	
2100	6.05	69.0	11.40	30.4	32.9	19.8	Mantle well filled.
2200	6.34	69.5	10.98	31.6	31.6	21.7	
2300	6.63	70.0	10.58	32.8	30.5	23.5	
2400	6.92	70.9	10.25	33.8	29.6	25.6	Air ports ¾ open.
2500	7.20	71.2	9.90	35.0	28.6	27.5	
2600	7.50	72.0	9.60	36.1	27.7	30.0	
2700	7.78	72.7	9.35	37.1	27.0	32.8	No visual difference in burner or mantle.
2800	8.07	73.3	9.09	38.2	26.2	35.2	
2900	8.36	74.0	8.86	39.2	25.5	39.0	
3000	8.65	74.6	8.63	40.2	24.9	42.4	
3100	8.94	75.0	8.40	41.3	24.2	46.0	

* Maximum efficiency. *See* also Fig. 1, Curve A.

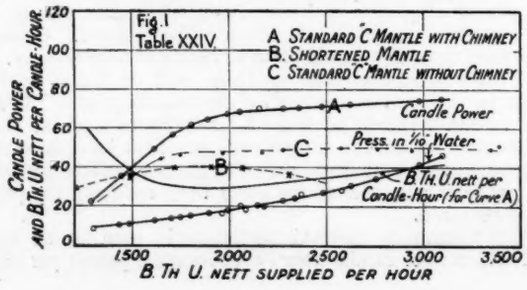


TABLE XXIVA.

No. 3 Burner. C Mantle. No Chimney.

B.Th.U nett per Hour supplied.	C.Ft. Gas supplied per Hour.	Candle Power.	Candles per C.Ft.	B.Th.U. nett per Candle Hour.	Candle Power per 1,000 B.Th.U. nett.	Press. Tenths Water Gauge.	Remarks.
1500	4.32	35	8.13	42.7	23.4	11.0	½ mantle heated Air-ports closed
1600	4.64	42	9.06	38.3	26.1	12.4	
*1700	4.90	46	9.40	36.9	27.1	13.5	Mantle ½ heated
1800	5.18	47.5	9.17	37.9	26.4	15.0	
1900	5.48	48.0	8.76	39.6	25.3	16.0	
2000	5.77	49	8.33	41.7	24.0	17.7	
2100	6.05	49	8.10	42.8	23.4	19.8	¾ mantle heated Air-ports ½ open.
2200	6.34	49	7.74	44.9	22.3	21.7	
2300	6.63	49.5	7.40	47.0	21.3	23.5	Air-ports full open.
2400	6.92	49.8	7.16	48.5	20.6	25.6	
2500	7.20	50.0	6.91	50.2	19.9	27.5	Some flame above mantle, which seems to be only ¾ heated, *i.e.*, unsuitable flame shape.
2600	7.50	50.0	6.68	51.9	19.3	30.0	
2700	7.78	50.0	6.43	53.9	18.6	32.8	
2800	8.07	50.0	6.20	56.0	17.9	35.2	
‡2900	8.36	50.2	6.00	57.8	17.3	39.0	
3000	8.65	50.0	5.78	60.0	16.7	42.4	
3100	8.95	49.8	5.57	62.4	16.0	46.0	
3200	9.23	49.6	5.38	64.5	15.5	47.2	

* Maximum efficiency.
‡ Maximum illuminating power. See also fig. 1, Curve C.

If we take as typical figures those at 6 c.ft. per hour, the illuminating power with the chimney is 69-candle power, and without, 48-candle power.

It had been suggested that a gas such as that now dealt with might give better results as regards thermal efficiency if used with a smaller mantle. A standard "C" size mantle was therefore cut-down to two-thirds of its original height. It is quite probable that the shape and proportions of the mantle also require alteration, and that the expedient of merely shortening an existing type of mantle does not meet the situation. The results were not satisfactory.

Burner No. 2.—This is the "No. 2" burner of the first report. On the gases of higher calorific value it proved distinctly more efficient than the "No. 1" burner, mainly owing to a higher degree of primary aeration and a mixing device for air and gas in the stem of the burner. It was

TABLE XXV.

Burner No. 2.—

Nipple not adjusted in any way, and contains 5 orifices, each 0·0266 in. dia.

Mantle—Glasmi XXX., size "C."

Chimney—Plain Cylindrical, 6 × 1⅛ ins.

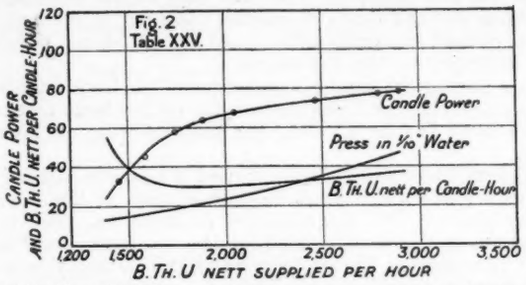
Calorific Value of Gas { 385 B.T.U. gross per c.ft. / 347 " net " } at 60° F. and 30 in. wet.

Specific Gravity—0·503.

B.Th.U nett supplied per Hour.	C.Ft. Gas supplied per Hour.	Candle Power.	Candles per C.Ft.	B.Th.U. nett per Candle Hour.	Candle Power per 1,000 B.Th.U. nett.	Press. Tenths Water Gauge.	Remarks.
1400	4.04	27.0	6.68	52.0	19.2	13.6	Air ports practically closed.
1500	4.32	39.2	9.06	38.3	26.1	15.0	
1600	4.62	48.7	10.52	32.9	30.4	17.0	
‡1700	4.90	56.0	11.42	30.4	32.9	18.3	
*1800	5.18	61.2	11.82	29.4	34.0	20.0	
1900	5.48	64.5	11.77	29.5	33.9	22.0	
2000	5.77	66.4	11.50	30.2	33.1	23.8	¾ mantle heated Air ports ½ open.
2100	6.05	68.2	11.27	30.8	32.5	26.0	
2200	6.34	70.0	11.05	31.4	31.8	28.0	
2300	6.63	71.4	10.77	32.2	31.1	30.0	
2400	6.92	72.9	10.53	32.9	30.4	32.5	
2500	7.20	74.6	10.37	33.5	29.9	35.0	
2600	7.50	75.2	10.03	34.6	28.9	37.7	
2700	7.78	76.5	9.84	35.3	28.3	41.0	
2800	8.07	77.5	9.60	36.2	27.6	44.0	¾ mantle heated Air ports ½ open.
2900	8.36	78.3	9.37	37.0	27.0	47.5	

* Maximum efficiency.

considered inadvisable to modify the nipple of this burner (in view of certain tests for which it is intended), but from experience with other burners it may be taken that the same illuminating powers and thermal efficiencies could have been obtained at lower pressures if the nipple had been opened-out, and further, the burner would give less trouble with air-adjustment than with the highly efficient and sensitive injector actually used in the tests. The gas issues from the burner-head in this case from a series of radially disposed slots. The results are stated in Table XXV. and fig. 2.



If Tables XXIV. and XXV. are compared, or better, if the corresponding curves are placed one above the other, it will be seen that at low consumptions the No. 2 burner is slightly inferior to the No. 1 burner, while if the consumption is increased, No. 2 is very slightly the better. The differences are, however, small.

From the point of view of thermal efficiency and illuminating power over that portion of the curve which would in general represent the working conditions of the burner (say, 1700 to 2100 B.Th.U. net per hour), there is little to choose between the two. It would therefore appear that the necessity for exact adjustment and highly efficient injectors is not so important as for the "richer" gases. A number of the comments following Table XXIV. are applicable in this case also, but it is unnecessary to repeat them here.

Burner No. 4.—Burner No. 4 was of a type still used to some extent for outdoor lighting, but almost obsolete for indoor lighting. (See fig. 16.)

The burner stem is in the form of a Venturi tube, and is surmounted by a conical mixing chamber with perforated sides. The gas-air mixture issues at the circumference of the truncated cone and receives a spiral motion at the moment of discharge.

The features of the burner are therefore a high degree of primary aeration and thorough mixing of gas and air. It was found necessary to fit an air-slide as well as to open-out the nipple so as to secure satisfactory working with the burner. Tests with other grades of gas have not been made by the Committee, using this burner; but it is reputed to give excellent results with high-grade gases. The results are given in Table XXVI. and fig. 3. The results given present several points of interest and importance.

The candle-power curve is of a totally different shape and slope from those of burners No. 3 and No. 2. Below 6 c.ft. per hour the illuminating power and thermal efficiency are much lower than for either of the above burners.

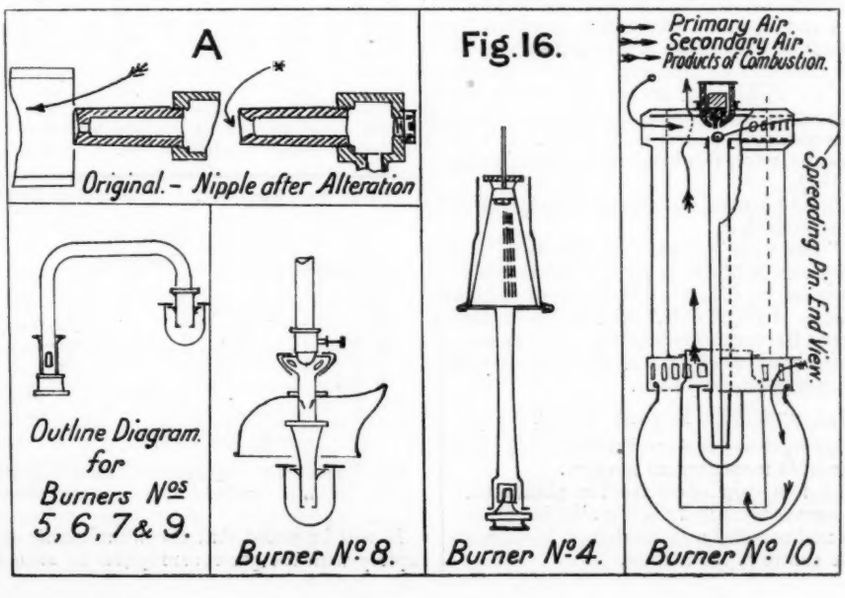
The B.Th.U. net per candle-hour curve, turns into a nearly horizontal direction at 6·5 c.ft. per hour, beyond which point the thermal efficiency increases slowly as the consumption is increased; but no true maximum thermal efficiency is obtained. Beyond 6·5 c.ft. per hour the illuminating power increases rapidly with consumption; and up to the limit of the tests at 12 c.ft. per hour the illuminating power was still increasing—the very high figure of 153-candle power being reached with a standard "C" size mantle.

There can be no doubt, therefore, that under suitable conditions the gas of low calorific value is capable of yielding.

TABLE XXVI.

Burner—No. 4.
Original dia orifices 0.0276″ = 0.00060 sq. ins. (each)
Altered „ „ 0.0342 = 0.00139 „ „
Relative areas $\frac{139}{60} = \frac{2.31}{1}$ (3 orifices in the nipple)
Mantle—Glasmi XXX. size C.
Chimney—Plain cylindrical 6 x $1\frac{7}{8}$″.
Calorific Value of Gas { 387 B.Th.U. gross per c. ft. / 349 „ nett „ „ } at 60° F. and 30″ wet.
Specific Gravity—0·500
No. 4 Burner. Size 'C' Mantle. Plain Chimney.

B.T.U. Nett. per Hour supplied.	Cu. ft. Gas supplied per hour.	Candle Power.	Candles per Cu. Ft.	B.T.U. Nett. per Candle Hour.	Candle Power per 1,000 B.T.U. Nett.	Press "tenths" Water Gauge.	Remarks.
1800	5.17	35	6.78	51.5	19.4	8.0	Air slide closed mantle well filled but dull.
1900	5.45	48	8.82	39.6	25.3	8.6	
2000	5.73	58	10.10	34.6	28.9	9.0	
2100	6.02	65	10.80	32.3	31.0	10.0	
2200	6.31	71	11.26	31.0	32.3	11.0	Very uniformly heated but not brilliant.
2300	6.60	75.5	11.44	30.5	32.8	11.8	
2400	6.88	79.5	11.55	30.2	33.1	12.9	
2500	7.17	84	11.73	29.8	33.6	14.0	
2600	7.45	88	11.81	29.5	33.9	15.0	
2700	7.74	92	11.90	29.3	34.1	16.2	
2800	8.03	96	11.94	29.2	34.2	18.0	Slight opening of air ports.
2900	8.31	100	12.04	29.0	34.5	19.2	
3000	8.60	104	12.10	28.8	34.7	21.0	
3100	8.89	108	12.15	28.7	34.8	22.0	
3200	9.17	112	12.22	28.6	35.0	23.5	
3300	9.45	116	12.30	28.4	35.2	25.0	Slight ruddy flame above mantle.
3400	9.74	120	12.33	28.3	35.3	26.5	
3500	10.03	124	12.35	28.3	35.3	28.0	
3600	10.32	128	12.38	28.2	35.5	29.0	
3700	10.61	132	12.43	28.1	35.6	31.0	Much escape of flame above mantle — not likely to be of use in practice.
3800	10.90	136	12.48	28.0	35.7	33.0	
3900	11.18	140	12.52	27.9	35.8	34.4	
4000	11.47	144	12.57	27.8	36.0	37.0	
4100	11.75	148.5	12.64	27.6	36.2	39.0	
4200	12.03	153	12.72	27.4	36.5	41.0	



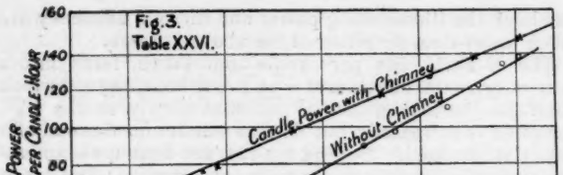


Fig. 3.
Table XXVI.
CANDLE POWER AND B.TH.U. NETT PER CANDLE-HOUR
Candle Power with Chimney
Without Chimney
B.Th.U. nett per Candle-Hour
Nipple Pressure in 1/10 Water
B TH. U. NETT SUPPLIED PER HOUR

very high candle powers. Even with this high gas consumption the thermal efficiency was greater than the average figure of 29 B.Th.U. net per candle-hour for the same gas with the other burners.

The potentialities of the gas burned under suitable conditions are here plainly indicated.

Table XXVIa. gives corresponding results for this burner used without a glass chimney.

TABLE XXVIa.

Conditions as above but without chimney.

B.T.U. nett per hr. supplied.	Cu Ft. gas supplied per hour.	Candle Power.	Candles per Cu. ft.	B.T.U. nett per Candle Hour.	Candle Power per 1000 B.T.U. Nett.	Press "tenths" Water Gauge.	Remarks.
2500	7.17	37	5.17	67.6	14.8	14.0	About ¾ mantle heated.
2600	7.45	51	6.85	51.0	19.6	15.0	
2700	7.74	60.5	7.83	44.6	22.4	16.2	Well filled but not brilliant.
2800	8.03	67.5	8.41	41.5	24.1	18.0	
2900	8.31	72.5	8.73	40.0	25.0	19.2	Flame seems to be just inside mantle.
3000	8.60	78	9.07	38.5	26.0	21.0	
3100	8.89	83.5	9.41	37.1	27.0	22.0	
3200	9.17	89	9.68	36.1	27.7	23.5	
3300	9.45	93.5	9.89	35.3	28.3	25.0	
3400	9.74	100.0	10.28	33.9	29.5	26.5	
3500	10.03	105.5	10.51	33.2	30.1	28.0	Mantle fully heated air ports ⅓ open.
3600	10.32	111.0	10.75	32.5	30.8	29.0	
3700	10.61	116.5	10.98	31.8	31.4	31.0	
3800	10.90	122	11.19	31.2	32.0	33.0	
3900	11.18	127.5	11.42	30.6	32.7	34.4	Flames above top mantle.
4000	11.47	133	11.58	30.1	33.2	37.0	Air ports full open.
4100	11.75	139	11.83	29.5	33.9	39.0	

SUMMARY WITH REGARD TO LOW-PRESSURE UPRIGHT INCANDESCENT BURNERS.

(1) If burners, correctly designed for gases of 500 B.Th.U. per cubic foot and upwards are simply modified by the enlargement of the nipple orifices, they can be used without difficulty at pressures under 20-10ths for this gas of 400 B.Th.U. gross per cubic foot; but if such modification is not made, it is impossible to deliver the necessary number of B.Th.U. without excessive pressure, while trouble ensues with aeration and lighting-back.

(2) With the modified burners, no unusual manipulative troubles are encountered.

(3) With the "C" size mantle, a perfectly steady light of some 70 to 75 candle power is readily obtainable at a gas consumption of 6 to 6·5 c.ft. per hour, with a thermal efficiency of about 29 B.Th.U. net per candle-hour. With one burner a much higher candle power (153 c.p.) was obtained with a thermal efficiency of 27·4 B.Th.U. net per candle-hour.

INVERTED INCANDESCENT BURNER TESTS.

Tests upon the Uddingston gas were carried out with a number of typical inverted incandescent burners.

These were mounted in turn upon the bar photometer used for the upright burner tests, and the illuminating power was for convenience and rapidity measured in a horizontal direction through the centre of the mantle.

Differing from the case of the upright burner, the measurement in a horizontal direction does not give the maximum illuminating power. Nevertheless the measurements may be taken as comparative if the mantles are properly filled with flame.

It may be taken that the measurement in a horizontal direction will be approximately 0·85 times that made at an angle of 30° to the horizontal, as in the Birmingham tests, and 0·75 to 0·80 times the maximum illuminating power. It is admitted that the above relationships are only approximate and that moreover they will vary slightly even with the same size and shape of mantle, according to the design of the burner, especially with regard to the burner nozzle, and its projection into the mantle.

In reporting the results, no adjustment has been made for the above factors, and with the exception of the large regenerative lamp (Table XXXII.) the mantles were all tested bare.

Several shades and globes were tried of a kind used locally, but none effected a measurable improvement in the illuminating power. The gas employed for these tests was very similar to that previously used for the ring-burner and upright incandescent burner tests and a typical analysis has already been given.

Burner No. 5.—This inverted burner is of the familiar type in which the gas nipple points upwards, and the mixed gas and air travel through a tube bent twice at right angles to the burner nozzle—thus affording reasonable protection against any contamination of the primary air supply with the products of combustion. The burner nozzle was of porcelain, and seemed to project less than usual into the mantle; the distance between the lugs carrying the mantle ring and the top of the nozzle being ½ in. The nipple was of the multiple-jet pattern, with a central orifice 0·0365 in. diameter always open, and three auxiliary orifices, of which one, two, or three could be brought into operation at once by means of a rotating diaphragm. An air-slide (fig. 16) was also fitted.

During the tests with the Uddingston gas all the jets were in operation. The results are set out in Table XXVII. and in fig. 4.

TABLE XXVII.

Burner—No. 5.
Nipple not modified in any way.
Mantle—Glasmi XXX.
Calorific Value of Gas { 385 B.Th.U. gross } per c.ft. at { 347 " nett } 60° F. 30" wet.
Specific Gravity—0·50.
Gas Analysis—*See* "Typical Analysis."

B.Th.U. Nett supplied per Hour.	Cu. Ft. Gas per hour.	Candle Power (Horizontal).	Candles per Cu. Ft.	B.Th.U. nett Candle Hour.	Candle Power per 1,000 B.Th.U. nett.	Nipple Press "tenths" Water Gauge.
1600	4.61	14.0	3.04	114	8.8	9
1700	4.90	24.7	5.08	68.3	14.6	10
1800	5.19	34.2	6.58	52.0	19.2	11
1900	5.48	43.3	7.90	43.9	22.8	12
2000	5.77	51.0	8.83	39.3	25.4	13
2100	6.05	57.0	9.43	36.8	27.2	14
*2200	6.34	60.7	9.59	36.2	27.6	15.5
**2300	6.63	63.0	9.50	36.5	27.4	17
2400	6.92	64.0	9.26	37.5	26.7	18.5
2500	7.21	64.0	8.88	39.1	25.6	20
2600	7.50	63.0	8.40	41.3	24.2	21.5
2700	7.78	62.0	7.97	43.6	22.9	23
2800	8.07	60.0	7.44	46.7	21.4	25
2900	8.36	57.5	6.68	52.0	19.2	27
3000	8.65	55.0	6.37	54.5	18.3	29

*Maximum Efficiency. **Maximum Illuminating Power.

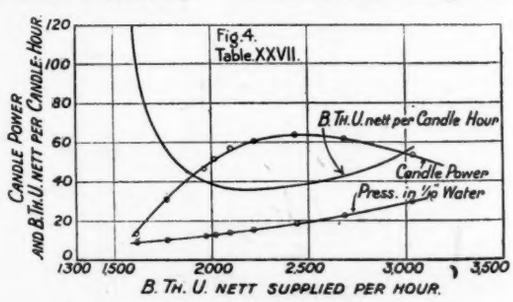


Fig. 4.
Table XXVII.
CANDLE POWER AND B.TH.U. NETT PER CANDLE-HOUR
B.Th.U. nett per Candle Hour
Candle Power
Press. in 1/10 Water
B. TH. U. NETT SUPPLIED PER HOUR.

It will be noted that the illuminating power rises very rapidly with the gas consumption to 2200 B.Th.U. net per

hour, at which point the mantle is uniformly heated, the air ports being very little open. This continues until 2700 B.Th.U. net per hour is reached, when, though the air-slide was fully open, and the burner noisy, there was an escape of unburned gas through the mantle ring and a noticeable falling-off in illuminating power.

It will be noted that the above results are inferior to the upright burner results at corresponding heat consumptions, and also to the other inverted burner results. There is nothing revealed on an examination of the burner that would lead one to expect such a reduction in performance, and the mantle appeared satisfactory to visual examination. The results are given, however, and serve to illustrate the variations which may be encountered in using the same grade of gas with different burners.

The pressures required to attain these results were not excessive and the maximum illuminating power was reached with less than 20-10ths pressure.

Similar results were obtained at lower pressures when the central orifice was opened-out to 0·055 in. diameter, though the air-slide was opened rather wider at corresponding gas rates.

With the central orifice opened-out to 0·072 in. diameter, an illuminating power of 61 candle power was attained with a nipple pressure of only 6-10ths and the thermal efficiency was substantially unaltered.

The results with this burner are not included in estimating average performances.

Burner No. 6.—Burner No. 6 was essentially of the same type as Burner No. 5, but was constructed throughout in metal. (See fig. 16.) The nipple was of simple construction, and modification to the extent indicated was made after preliminary trials. The results are expressed in Table XXVIII. and fig. 5.

TABLE XXVIII.

Burner—No. 6.
Nipple contains 3 orifices of fixed diameter.
Original dia. of orifices = 0.0254" = 0.00051 sq. ins.
Modified " " " = 0.0332" = 0.00087 " "
∴ Relative areas = $\frac{87}{51} = \frac{1.70}{1}$
Distance between Tip of nozzle and supports for mantle ring = 9/16"
Mantle—Glasmi XXX.
Calorific Value of Gas { 385 B.Th.U. gross } per c. ft. at { 349 " nett } 60° F. 30" wet.
Specific Gravity—0.500.
Analysis—*See* "Typical Analysis."

B.Th.U. Nett. supplied per Hour.	Cu. Ft. Gas per Hour.	Candle Power (Horizontal).	Candles per Cu. Ft.	B.Th.U. nett per Candle Hour.	Candle Power per 1000 B.Th.U. nett.	Nipple Press. "tenths" Water Gauge.
1600	4.58	49.0	10.70	32.6	30.7	15
1700	4.87	55.0	11.30	30.9	32.4	16
1800	5.16	61.0	11.83	29.5	33.9	17
1900	5.45	66.0	12.13	28.8	34.7	18
2000	5.74	72.0	12.54	27.8	36.0	19.5
*2100	6.02	75.8	12.60	27.7	36.1	21
2200	6.31	77.7	12.31	28.3	35.2	23
**2300	6.60	78.1	11.82	29.5	33.9	25
2400	6.88	77.5	11.26	31.0	32.3	27
2500	7.17	77.0	10.74	32.5	30.8	30
2600	7.46	76.2	10.21	34.2	29.2	33
2700	7.74	75.8	9.80	35.6	28.1	36
2800	8.02	75.0	9.36	37.3	26.8	40

*Maximum Efficiency. **Maximum Illuminating Power.

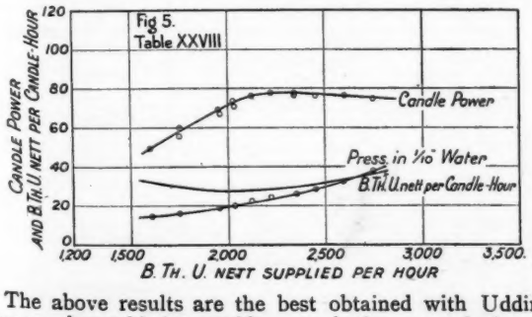


Fig 5.
Table XXVIII
CANDLE POWER AND B.TH.U NETT PER CANDLE-HOUR
Candle Power
Press. in 1/10" Water
B.Th.U. nett per Candle-Hour
B. TH. U. NETT SUPPLIED PER HOUR

The above results are the best obtained with Uddingston gas, burned in inverted burners, both as regards thermal efficiency and attainable candle power (regenerative burner excluded); and the results as regards thermal efficiency are appreciably better than for some of the upright burners at the same gas consumptions. From observation of the pressures required, it is possible that the nipple orifices might have been opened-out a little further, although the pressures required to reach the maximum illuminating power are not excessive.

Burner No. 7.—This burner was very similar to Burner No. 6, and was recommended by the makers for use with debenzolized gas and gases of lower calorific value than the normal. It was provided with a porcelain nozzle, and the nipple was surrounded by a mixing chamber of ample proportions. There were five orifices in the nipple, each of 0·0244 in. diameter, and the effective number could be controlled by means of a rotating plug. (See fig. 16.) The nozzle projected well into the mantle. The results are indicated in Table XXIX. and fig. 6.

TABLE XXIX.

Burner—No. 7.
No alteration made to the nipple.
Distance between tip of nozzle and supports for mantle ring = 5/8" full.
Mantle—Glasmi XXX.
Calorific Value of Gas { 385 B.Th.U. Gross } per c.ft. at { 347 " Nett } 60° F. 30" Wet.
Specific Gravity—0.50.
Analysis—*See* "Typical Analysis."

B.Th.U. Nett. Supplied per Hour.	C.Ft. Gas per Hour.	Candle Power (Horizontal).	Candles per Cu Ft.	B.Th.U. Nett. per Candle Hour.	Candle Power per 1000 B.Th.U. Nett	Nipple Press "tenths" Water Gauge.
1400	4.04	26	6.44	54	18.5	12
1500	4.32	33	7.65	45.4	22.0	13
1600	4.62	40	8.69	40.0	25.0	14
1700	4.90	47	9.60	36.2	27.6	15
1800	5.18	52	10.05	34.5	28.9	16.5
1900	5.48	58	10.60	32.8	30.5	18
2000	5.77	62.5	10.82	32.1	31.2	19.5
2100	6.05	67	11.08	31.4	31.8	21.5
*2200	6.34	70.5	11.12	31.2	32.1	23
2300	6.63	73	11.00	31.5	31.8	25
2400	6.92	74.8	10.81	32.1	31.2	26.5
**2500	7.20	75.2	10.45	33.2	30.1	28.5
2600	7.50	75.2	10.04	34.5	28.9	31
2700	7.78	74.6	9.60	36.2	27.6	33
2800	8.07	74.0	9.20	37.7	26.5	35.5
2900	8.36	73.2	8.75	39.7	25.2	38
3000	8.65	72	8.32	41.7	24.0	41
3100	8.94	70	7.84	44.3	22.6	44
3200	9.23	68	7.37	47.2	21.2	46

*Maximum Efficiency. **Maximum Illuminating Power.

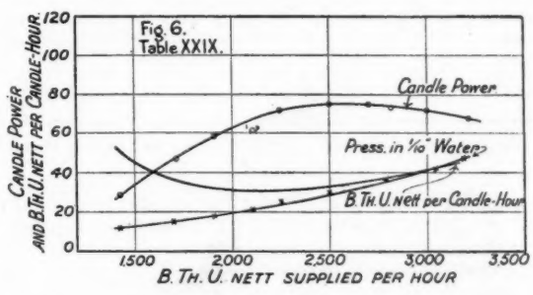


Fig. 6.
Table XXIX.
CANDLE POWER AND B.TH.U. NETT PER CANDLE-HOUR
Candle Power
Press. in 1/10" Water
B.Th.U. Nett per Candle-Hour
B. TH. U. NETT SUPPLIED PER HOUR

The above results show that this burner is somewhat inferior to the previous burner as regards thermal efficiency and maximum illuminating power, although its general behaviour is much the same. The orifices might have been opened-out a little, with advantage, to reduce the nipple pressures required.

Burner No. 8.—This burner was of a pattern in common use, but represents a different type from those previously tried. The injector is immediately above the burner; and injector, air-ports, and burner nozzle lie about a common vertical axis. Contamination of the primary air supply with products of combustion is prevented by means of a deflecting hood. (See fig. 16.)

The nipple is in the form of a single orifice of comparatively large diameter; the effective area being controlled by the depression of a suitably shaped pin.

The air injection caused by such a device is good when it is well made and accurately adjusted; but it is liable to erratic behaviour from various causes, the most common

of which seem to be mechanical damage to the pin, or to the periphery of the orifice, and liability to an eccentric position of the pin in the orifice.

This type of nipple provides a ready and flexible means of adjustment, and the defects referred to are more important in testing than in commercial work, especially when it is desirable to be able to repeat adjustments exactly.

For gases of low calorific value, the variations in injector efficiency become much less important than for those of high calorific value, which require good workmanship and accurate adjustment if a high efficiency is to result.

In the present case the orifice of the nipple was broached-out to twice its original diameter; but the effective alteration in area with the pin in position is rather difficult to estimate.

In the case of this burner the porcelain nozzle projects a considerable distance into the mantle. The effect of this will be noted later.

The results obtained are indicated by Table XXX. and fig. 7. It will be observed that the illuminating power curve in this case is of a different shape from that of the other burners. This is almost entirely due to the nozzle coming further into the mantle, whereby a larger proportion of the mantle becomes effective at the lower gas consumptions.

TABLE XXX.

Burner—No. 8.

Nipple modified as indicated above.

Distance between tip of burner nozzle and supports for mantle ring = $\frac{7}{8}$".

Mantle—Glasmi XXX.

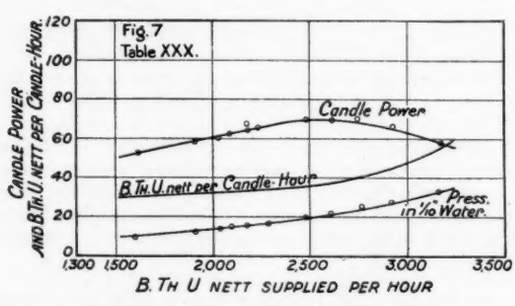
Calorific Value of Gas { 385 B.Th.U. gross } per cu.ft. at { 349 ,, nett } 60° F. 30" wet.

Specific Gravity—0.50.

Analysis—*See* "Typical Analysis."

B.Th.U. Nett. Supplied per Hour.	Cu.Ft. Gas per Hour.	Candle Power. (Horizontal)	Candles per Cu.Ft.	B.Th.U. Nett per Candle Hour.	Candle Power per 1000 B.Th.U. Nett.	Nipple Press. "tenths" Water Gauge.
*1600	4.58	52.5	11.42	30.5	32.8	10
1700	4.87	54.5	11.20	31.2	32.0	11
1800	5.16	56.5	10.97	31.8	31.4	12
1900	5.45	58.5	10.74	32.5	30.8	12.5
2000	5.74	60.7	10.58	33.0	30.3	13.5
2100	6.03	62.7	10.40	33.6	29.8	14.5
2200	6.32	65.0	10.29	33.9	29.5	15.5
2300	6.60	67.2	10.18	34.3	29.2	16.5
2400	6.88	69.0	10.03	34.7	28.8	18
**2500	7.17	70.0	9.77	35.8	27.9	19.5
2600	7.46	69.8	9.35	37.3	26.8	21
2700	7.74	68.9	8.90	39.2	25.5	23
2800	8.03	67.5	8.40	41.6	24.0	24.5
2900	8.32	65.5	7.88	44.3	22.6	26.5
3000	8.60	63.0	7.33	47.6	21.0	28.5
3100	8.89	60.5	6.81	51.3	19.5	31
3200	9.18	57.5	6.27	55.8	17.9	34

*Maximum Efficiency. **Maximum Illuminating Power.



This construction also causes the lower portion of the mantle to be heated more strongly than the upper part; and hence the most strongly illuminated zone is not favourably disposed for measurement in a horizontal direction.

This factor will reduce to some extent the apparent inferiority of this burner, so that Burners Nos. 6, 7, and 8 may be taken as giving essentially similar results for the same heat consumption.

Burner No. 9.—In addition to the foregoing burners of standard size, tests were made with a bijou burner of simple construction. (See fig. 16.) The results are given

TABLE XXXI.

Burner—No. 9.

Nipple contains a single orifice opened out to 0.031" dia. to deliver sufficient gas.

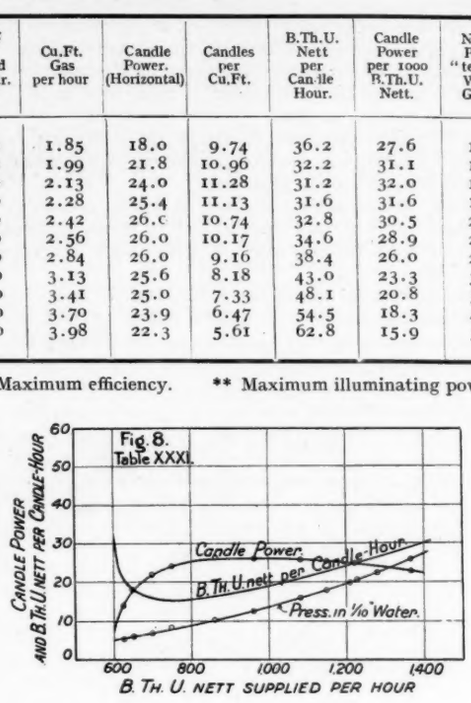
Calorific Value of Gas { 391 B.Th.U. gross } per c. ft. at { 352 ,, nett } 60° F. 30" wet.

Specific Gravity—0.50.

Analysis—See "Typical Analysis."

B.Th U Nett supplied per Hour.	Cu.Ft. Gas per hour	Candle Power. (Horizontal)	Candles per Cu.Ft.	B.Th.U. Nett per Candle Hour.	Candle Power per 1000 B.Th.U. Nett.	Nipple Press. "tenths" Water Gauge.
650	1.85	18.0	9.74	36.2	27.6	12
700	1.99	21.8	10.96	32.2	31.1	14
*750	2.13	24.0	11.28	31.2	32.0	16
800	2.28	25.4	11.13	31.6	31.6	18
**850	2.42	26.c	10.74	32.8	30.5	20
900	2.56	26.0	10.17	34.6	28.9	22.5
1000	2.84	26.0	9.16	38.4	26.0	27.5
1100	3.13	25.6	8.18	43.0	23.3	33
1200	3.41	25.0	7.33	48.1	20.8	39
1300	3.70	23.9	6.47	54.5	18.3	46
1400	3.98	22.3	5.61	62.8	15.9	56

* Maximum efficiency. ** Maximum illuminating power.



in Table XXXI. and fig. 8. The table shows that the illuminating power usually expected from the bijou burner can be readily attained with Uddingston gas. The thermal efficiency in these tests is slightly lower for the bijou burner than for the ordinary size.

Burner No. 10 (High-Power Low-Pressure Lamp).—Although strictly speaking such burners are outside the range of domestic lighting, the opportunity was taken of testing at Uddingston a specimen of a high-power low-pressure lamp. Here the mixture of gas and primary air receives a certain amount of pre-heating in passing down a central tube heated externally by the products of combustion from the burner. The secondary air is also heated by passing between an inner and outer globe. (See fig. 16.)

The injector is highly efficient; and when it is desirable to reduce primary aeration in dealing with the gases of lower calorific value this is done by placing a regulating pin in the path of the issuing gas jet, thereby reducing the power of injection. The mantle is considerably larger than for the domestic size of burner and is practically cylindrical in shape; so that the horizontal measurement in this case more nearly approaches the maximum illuminating power. The results are expressed in Tables XXXII (A, B, C) and in fig. 9.

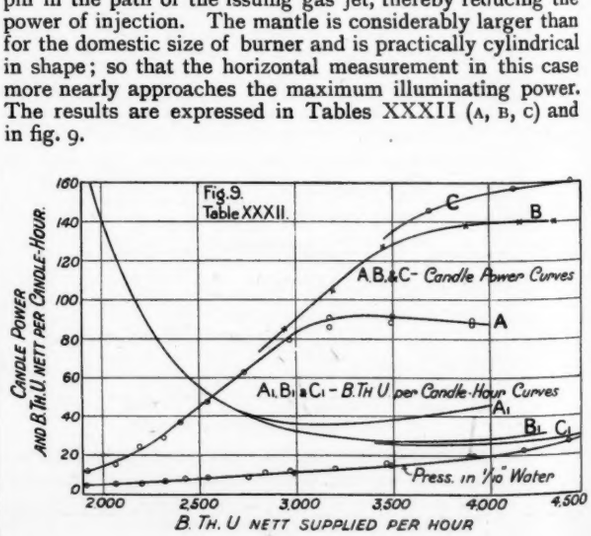


TABLE XXXIIA.

Burner—No. 10.
Mantle—Graetzin.
Calorific Value of Gas {385 B.Th.U. gross / 347 „ nett} per c.ft. at 60°F. 30" wet.
Specific Gravity—·500.

Mantle tested bare.

B.Th.U. Nett. supplied per Hour.	Cu. Ft. Gas per Hour.	Candle Power. (Horizontal).	Candles per Cu. Ft.	B.Th.U. Nett per Candle Hour.	Candle Power per 1000 B.Th.U. Nett.	Nipple Press., "Tenths" Water Gauge.
2000	5.74	14.0	2.44	143.0	7.0	5.0
2100	6.03	18.2	3.02	111.5	9.0	5.9
2200	6.32	23.2	3.77	92.6	10.8	6.4
2300	6.60	30.0	4.55	76.7	13.0	7 0
2400	6.88	37.9	5.52	63.3	15.8	7.8
2500	7.17	45.4	6.34	55.1	18.1	8.3
2600	7.46	53.0	7.11	49.1	20.4	9.0
2700	7.74	60.6	8.13	43.0	23.3	9.7
2800	8.03	68.1	8.48	41.2	24.3	10.2
2900	8.32	75.9	9.24	37.8	26.5	11.0
3000	8.60	84.1	9.78	35.7	28.0	11.7
3100	8.89	88.0	9.91	35.2	28.4	12.2
3200	9.18	90.5	9.86	35.4	28.2	12.5
3300	9.46	91.7	9.69	36.0	27.8	13.1
3400	9.75	91.7	9.40	37.1	27.0	14.0
3500	10.03	91.2	9.08	38.4	26.0	14.9
3600	10.32	90.3	8.75	39.9	25.1	15.8
3700	10.61	89.5	8.43	41.4	24.2	16.8
3800	10.89	89.0	8.17	42.7	23.4	17.9
3900	11.18	88.4	7.92	44.1	22.7	19.0
4000	11.47	87.8	7.67	45.5	22.0	20.1

When used in this manner, the burner is obviously giving an inferior performance as regards thermal efficiency.

TABLE XXXIIB.

Mantle surrounded by a cylindrical shade. All other conditions as in Table XXXIIA.

B.Th.U. Nett. Supplied per Hour.	Cu.Ft. Gas per Hour.	Candle Power (Horizontal).	Candles per Cu.Ft.	B.Th.U. Nett. per Candle Hour.	Candle Power per 1000 B.Th.U. Nett.	Nipple Press. "Tenths" Water Gauge.
2800	8.03	73.0	9.09	38.4	26.0	10.2
2900	8.32	86.0	10.34	33.8	29.6	11.0
3000	8.60	89.0	10.34	33.8	29.6	11.7
3100	8.89	97.4	10.96	31.9	31.3	12.2
3200	9.18	106.1	11.57	30.2	33.1	12.5
3300	9.46	115.2	12.19	28.6	35.0	13.1
3400	9.75	123.3	12.67	27.6	36.2	14.0
3500	10.03	128.8	12.84	27.2	36.8	14.9
3600	10.32	132.8	12.87	27.1	36.9	15.8
3700	10.61	136.6	12.87	27.1	36.9	16.8
3800	10.89	137.4	12.63	27.6	36.2	17.9
3900	11.18	138.7	12.40	28.2	35.5	19.0
4000	11.47	139.1	12.15	28.7	34.8	20.1
4100	11.76	139.5	11.87	29.4	34.0	21.9
4200	12.04	140.0	11.63	30.0	33.3	23.3

The improvement effected by the addition of the shade is very evident, and the thermal efficiency is the highest attained with Uddingston gas.

TABLE XXXIIC.

Burner as in Table XXXIIB., but outer globe added in addition to inner shade, *i.e.*, complete lamp as ordinarily used.

B.Th.U. Nett. Supplied per Hour.	Cu.Ft. Gas per Hour.	Candle Power. (Horizontal)	Candles per Cu.Ft.	B.Th.U. Nett per Candle Hour.	Candle Power per 1000 B.Th.U. Nett.	Nipple Press. "tenths" Water Gauge.
3500	10.03	135	13.44	26.0	38.5	14.9
3600	10.32	141	13.67	25.6	39.1	15.8
3700	10.61	146	13.75	25.4	39.4	16.8
*3800	10.89	150	13.79	25.3	39.5	17.9
3900	11.18	153	13.69	25.5	39.2	19.0
4000	11.47	155	13.52	25.8	38.8	20.1
4100	11.76	156.5	13.31	26.2	38.2	21.9
4200	12.04	158	13.12	26.6	37.6	23.3
4300	12.31	159	12.92	27.0	37.0	25.0
4400	12.60	160	12.70	27.5	36.4	26.8
4500	12.89	160	12.52	27.9	35.8	—
4600	13.18	160.5	12.18	28.6	35.0	—
4700	13.47	161	11.94	29.2	34.2	—
4800	13.75	161	11.71	29.8	33.6	—
4900	14.04	161.5	11.49	30.4	32.9	—
5000	14.32	162	11.31	30.9	32.4	—

*Maximum efficiency.

The further improvement effected by the use of the complete lamp is here shown and the suitability of Uddingston gas for lamps of this size is demonstrated.

SUMMARY WITH REGARD TO INVERTED INCANDESCENT BURNERS.

A summary of the position of Uddingston gas of this quality with regard to use in low-pressure inverted burners would be very largely a repetition of that already given for the upright incandescent burners.

It will be noted that the thermal efficiencies given for the inverted burners are slightly lower than for the upright burners. If, however, we take into account the fact that the measurements were made in a horizontal direction, which does not represent the maximum candle power in the case of the inverted burner, and that no chimneys were used, this would, in all probability, make the thermal efficiency of the inverted burner slightly greater than that of the upright burner.

GENERAL SUMMARY FOR UDDINGSTON TESTS.

Gas of the quality tested at Uddingston, of approximately 400 B.Th.U. gross per c.ft., can be used in ordinary burners for either low or high temperature work if the nipple orifice is increased in area to allow of the delivery of the greater volume of gas required. This being done, the use for low temperature work (*e.g.*, in the ring-burner) offers no difficulty; and the thermal efficiency is the same as that already found for gas of higher calorific value. With the incandescent lighting burner taken as representing the most stringent requirements of high-temperature domestic use, the maximum efficiency under test conditions is a little lower than the best obtainable with gas of a higher calorific value, but is much more easily and consistently obtained. In ordinary use the efficiency is probably at least equal in existing appliances, which it must be remembered have been evolved to deal with gas of a higher calorific value. Pressures below 20-10ths are sufficient to maintain the injector efficiencies necessary for satisfactory working.

In considering lighting, comparison here and throughout the report has been made on the basis of a thermal efficiency defined as the B.Th.U. necessary for the production of one candle-power-hour. Any such comparison of different gases on the basis of candle power per cubic foot is inapplicable, although this figure is useful for comparison of different burners used on the same gas and for the planning of installations to give specified illumination.

PART II.

Relative Efficiencies in Use of Different Grades of Gas—*continued.*

LIGHTING WITH LOW-PRESSURE UPRIGHT BURNERS.

The present section is a direct continuation of the lighting section of the first report. In that section relatively low illuminating powers as well as low thermal efficiencies were reported for upright incandescent burners, for reasons explained in the Committee's reply to the discussion. The fact that no chimney was used in the first tests, in order to obtain the simplest possible conditions of operation and comparison, would in itself reduce the thermal efficiency by at least 25 p.ct. of the maximum obtainable from the burner. It should be pointed out, however, that many upright burners are used in this unprotected condition, or with shades which protect the mantle from draughts, but whose usefulness as chimneys is questionable. The same applies also to street lighting, where the lantern is sometimes the only protection afforded to the mantle.

Figures given in Table XXXIII. illustrate the degree to which the use of a chimney affects the results.

They were obtained with the burner used for previous tests (No. 1) and were arranged to determine the maximum attainable candle power for this burner, with the restriction that the burner was not to be altered in the slightest degree, and that nipple pressures greater than 20-10ths were not to be employed. The figures given represent the results of isolated tests, and as such do not carry the same weight as those of the systematic tests reported later. They do, however, demonstrate the improvement effected by the use of a chimney, the results being from 20 to 25 p.ct. better than the corresponding results in the first report.

The relatively small variation in thermal efficiency and in attainable candle power as the gas quality is altered over the range indicated will be noted.

TABLE XXXIII.

Type of Gas.	Calorific Value.		Partial Analysis.			Spec. Grav.	Press. 'tenths' Water Gauge.	B.Th.U. nett Hour supplied.	Gas Rate Cu. Ft. Hour.	Candle Power.	Candles per Cu. Ft.	B.Th.U. nett Candle Hour.	Candle Power per 1.000 B.Th.U. nett.
	Gross.	Nett.	CO_2.	O_2.	N_2.								
1 Coal Gas ..	572	517	2.6	0.9	21.0	0.538	20	2,280	4.42	82	18.6	27.8	36.0
2 Coal Gas .. (Vertical Retorts)	551	496	3.0	1.1	9.4	0.512	10 20	1,760 2,480	3.55 5.00	60 79	16.9 15.8	29.4 31.4	34.0 31.8
3 Coal Gas ..	545	489	3.0	1.1	12.0	0.519	13.5 20	1,908 2,377	3.90 4.86	60 85	15.4 17.5	31.8 28.0	31.4 35.7
4 Coal Gas & B.W.G.	511	463	3.3	1.2	12.4	0.508	20	2,095	4.53	71	15.7	29.6	33.8

TESTS USING MIXTURES OF COAL GAS AND BLUE WATER GAS IN DIFFERENT PROPORTIONS.

The tests about to be described were carried out under particularly favourable conditions for obtaining reliable comparative results.

Two large experimental gasholders were available, one of which was filled with coal gas and the other with blue-water gas. Tests were carried out upon the coal gas, which was then diluted with blue-water gas from the other holder. After tests upon this mixture, the residual gas was still further diluted, and so on.

Except for such minor charges as have taken place owing to the gases standing for some time over water (mainly the partial removal of CO_2) the mixtures represent successive additions of the same quality of water gas, and the results aimed at were mixtures containing approximately 12·5, 25, 37·5 and 50 p.ct. of their volume of blue-water gas.

The compositions of these mixtures are represented in Table XXXIV., by gases A to E respectively. Other gas mixtures have been added for convenience of reference and comparison.

The coal gas employed was a straight coal gas from horizontal retorts without stripping. The blue-water gas was made in a carburetted water gas plant and the somewhat high CO_2 content is in part due to inability to completely purge the carburettor and superheater from "blow gases." There is evidence to show that about 0·5 p.ct. unsaturated hydrocarbons was present, owing to the manner of working the water gas plant.

The analyses given are the determined analyses for the respective mixtures. They are in fair agreement with those anticipated from the proportions in which the coal gas and blue-water gas are mixed.

It will not be out of place at the present stage to compare certain of the physical, chemical, and thermal properties of the gas mixtures used (Table XXXIV.).

Throughout the series, the inerts show only unimportant changes. As the calorific value is reduced, the methane and unsaturated hydrocarbons undergo reduction practically in proportion. Owing to the composition of the original gases, the hydrogen content of the mixture suffers no material change while there is a marked increase in the percentage of carbon monoxide as the proportion of blue water gas is increased. The specific gravity of the gas mixtures ranges between ·44 and ·49.

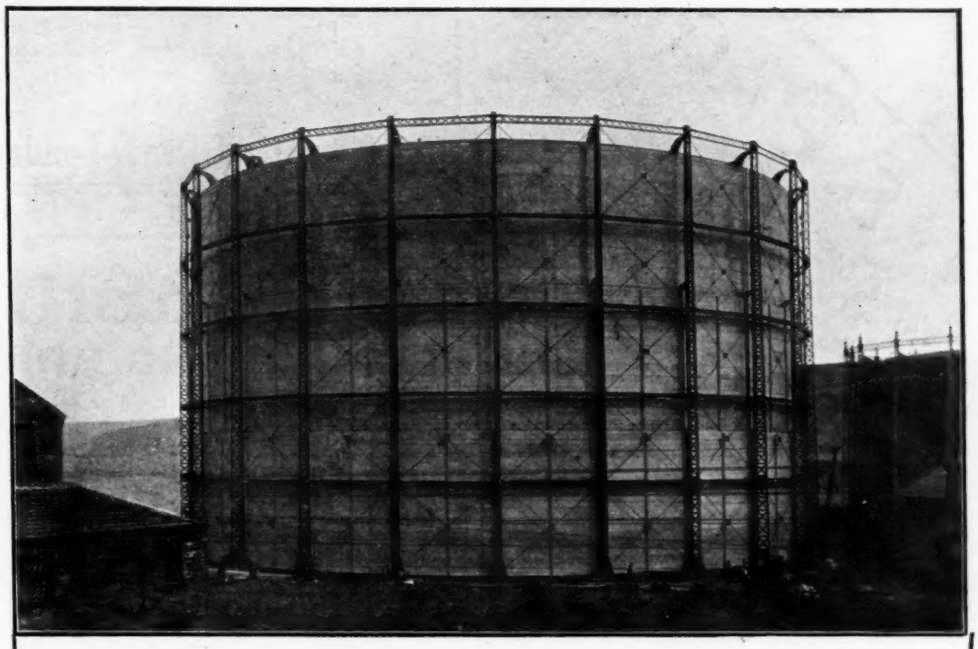
In passing, it may be noted that if the calorific value had been reduced to the same extent (viz., to 450 B.Th.U. gross) by the introduction of inerts, the specific gravity would have risen to at least ·60.

TABLE XXXIV.

	A	B	C	D	E	I	H	F	G
Percentage of B W.G in Mixture.	Nil.	13.0 per. cent.	23.8 per cent.	35.5 per cent.	51 8 per cent.	70 per cent.	100 per cent.	Uddingston Tests.	
Composition									
CO_2	1.6	2.2	2.8	2.9	3.7	5.9	7.7	6.1	3.6
O_2	0.7	0.7	0.4	0.4	0.3	0.4	0.3	0.3	0.7
HC	4.0	3.5	3.1	2.7	2.0	1.2	0.0	1.0	1.5
CO	7.0	11.4	14.0	17.2	22.0	27.1	35.7	23.9	14.5
H_2	44.7	45.7	46.3	46.8	47.6	47.6	48.9	50.1	49.2
CH_4	35.8	30.6	27.3	23.6	18.2	11.9	1.6	12.2	23.3
N_2	6.2	5.9	6.2	6.2	6.2	5.9	5.8	6.4	7.2
	100.0	100.0	100.1	99.8	100.0	100.0	100.0	100.0	100.0
Total Inerts	8.5	8.8	9.4	9.5	10.2	12.1	13.8	12.8	11.5
Inerts in "air-free" gas ..	5.2	5.5	7.5	7.6	8.8	10.3	12.4	11.4	8.2
Sp. Gr.	0.44	0.45	0.46	0.47	0.49	0.53	0.57	0.50	0.46
Calorific Value	618	572	541	506	453	389	291	388	476
B.Th.U. Gross per c. ft. at	556	516	486	455	409	353	267	345	423
" Net 30°60°F.wet									
Vol. air per c. ft. gas ..	5.47	4.99	4.68	4.33	3.81		2.15	3.10	4.02
B.Th.U. per c. ft. Gross	95.6	95.6	95.3	94.9	94.4		92.5	94.6	94.0
G.+A. mixture Net	86.2	86.2	85.7	85.2	85.0		84.7	86.5	84.3
Vol prods. combustion per c. ft. gas Total ..	6.23	5.62	5.40	5.02	4.47		2.73	3.80	4.71
H_2O Condensed	4.95	4.55	4.29	4.00	3.57		2.21	3.00	—
B.Th.U. Net per c. ft. prods.	89.4	91.8	90.2	90.6	91.5		97.6*	91.0	89.8
Composition of Products of Combustion by volume CO_2	9.1	9.8	9.9	10.3	11.3		16.5		
O_2	20.6	19.2	20.4	20.4	20.1		19.1		
N_2	70.3	71.0	69.7	69.3	68.6		64.5		

*These calculated values for the water gas are vitiated by the presence of unsaturated hydrocarbons, not determined in the analysis. A figure of 94 to 95 B.Th.U. net per cubic foot of products of combustion would be a better estimate, and more in harmony with the other analyses. The air requirement also is probably under-estimated.

W. C. HOLMES & CO. LTD.



GASHOLDER ERECTED AT HUDDERSFIELD, 1914

(Capacity 4½ Million Cubic Feet.)

. . .

GASHOLDERS

Spiral or Column Guided

AND STEEL TANKS

. . .

STRUCTURAL STEELWORK
STEEL MAINS, &c.

HUDDERSFIELD

AMMONIA AND TAR PRODUCTS.

CHAS. PAGE & Co., Ltd.

MERCHANTS. 47/51, KING WILLIAM ST., LONDON, E.C. EXPORTERS.

Suppliers of Benzol Washing Oil.

Established 100 Years.

TILLEY BROS.

are prepared to undertake Contracts for Fitting-up houses for Automatic Gas Supplies in all parts of the United Kingdom, supplying Meters, Cookers, Gas Fittings, Burners, &c., and Piping Complete, or for Piping Work Only.

53, Kingsland Road, London, E.2

"HOBSIL"

INSULATING BRICKS

9 in. × 4½ in. × 2 in.

Fusion Point, approx. 3000 Fahr.

FOR

Gas Retorts, Ovens, &c.

HOBDELL, WAY, & CO., LTD.

124-7, Minories, LONDON, E. 1.

Telegrams—"Hobnails." Telephones—Avenue 3810 (8 lines).

Sam! Cutler & Sons Ltd

Engineers and Contractors

Complete plants for the production of

Coal Gas, Water Gas, Hydrogen Gas.

Prudence Jane Works, Millwall. London. 59 Victoria Street, Westminster.

There are noteworthy differences in the air requirements per cubic foot of gas for the different mixtures; but it must be pointed out that the quantities are related to one another in such a manner that the value for heat units available per cubic foot of (theoretical) gas-air mixture is constant within 2 p.ct.

This constancy is not peculiar to the mixtures of the present series of tests, but seems to obtain generally with the wider range of mixtures we have tested. The same is substantially true of the volume of products of combustion per cubic foot of gas, and of the heat units developed per cubic foot of products of combustion. The calculated composition of the products of complete combustion is very similar throughout.

From the foregoing considerations and an analysis of the thermal data only, for each of the above gas mixtures, there is no solid ground for expecting one mixture to give better results than another, provided always that the apparatus in use will permit of both generating heat units at the same rate. Actual experiment, however, reveals differences, by no means negligible.

Any differences observed may be accounted for by matters not indicated by the thermal analysis—such as size and shape of flame, manner and rate of combustion, and the extent to which the actual mixture conditions at the burner head approximate to the theoretical indicated in Table XXXIV.

METHOD OF TESTING.

As before, the burner was tested upon a 60 in. bar photometer; the illuminating power being measured in a horizontal direction through the centre of the mantle—*i.e.*, the maximum illuminating power.

BURNER USED—BURNER NO. 2.

These experiments were made with a burner in common use, which some tests had shown to be more efficient than No. 1. [See first report.] This burner (No. 2) was rather more elaborate in construction than the previous burner, with a device for causing the thorough mixing of gas and air before reaching the burner-head. The injector seemed to be very efficient, and the workmanship of the burner was good. Throughout the tests, a "C" size mantle was employed, with a plain cylindrical chimney 6 in. by $1\frac{7}{8}$ in. diameter.

Tables XXXV. to XXXIX. give the necessary details of the tests, which are, however, best reviewed collectively.

The relevant Uddingston results [see Table XXV.] conform with these, and since they carry the tests to still lower calorific values they are included for purposes of comparison in Table XL.

The mantle is well filled with flame, even at 3·24 c.ft. per hour; but the brilliancy is not good. As the gas consumption and aeration are increased, the brilliancy improves up to 4·68 c.ft. per hour. Beyond this point, very careful adjustment is necessary, or the illuminating power may fall 25 to 30 candle power below the values indicated in the table.

TABLE XXXV.

Gas Used.—Straight Coal Gas "A"—in Table XXXIV.

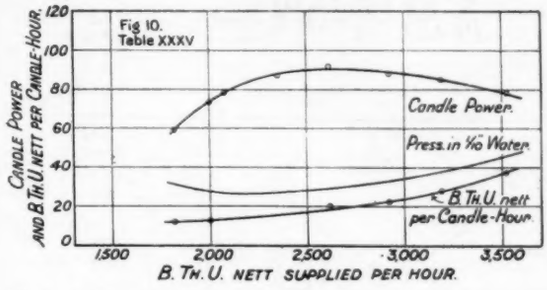
Calorific Value { 618 B.Th.U. gross } per cubic foot at 60°F.
{ 556 ,, nett } and 30" wet.

Sp. Gr. 0.44

See also fig. 10.

B.Th.U. nett. Supplied per Hour.	Cu. Ft. Gas per Hour.	Candle Power.	Candles per Cu. Ft.	B.Th.U. nett per Candle Hour.	Candle Power per 1000 B.Th.U. Nett.	Nipple press "te. ths" Water Gauge.
1800	3.24	57.0	17.60	31.6	31.6	12
1900	3.42	66.0	19.30	28.8	34.7	12.5
2000	3.60	73.6	20.45	27.2	36.8	13
2100	3.78	79.8	21.15	26.3	38.0	13.5
*2200	3.96	84.0	21.22	26.2	38.2	14
2300	4.14	87.3	21.10	26.4	37.9	15
2400	4.32	89.0	20.63	26.9	37.2	16
2500	4.50	90.1	20.02	27.8	36.0	17
**2600	4.68	90.5	19.34	28.8	34.7	18
2700	4.86	90.5	18.62	29.9	33.4	19
2800	5.04	90.0	17.85	31.2	32.1	20.5
2900	5.22	89.0	17.04	32.6	30.7	22
3000	5.39	88.0	16.33	34.0	29.4	24
3100	5.57	86.6	15.60	35.7	28.0	26
3200	5.75	84.7	14.73	37.8	26.5	28
3300	5.93	82.8	13.95	39.9	25.1	30
3400	6.11	80.6	13.20	42.2	23.7	33
3500	6.29	78.2	12.45	44.7	22.4	36
3600	6.47	76.0	11.73	47.4	21.1	40

* Maximum Efficiency. ** Maximum Illuminating Power.



This is the only curve showing a distinct maximum illuminating power in addition to a point of maximum efficiency—a feature which would seem to be intimately connected with injector efficiency, and the ability of the burner to entrain sufficient primary air for dealing efficiently with a gas of this high calorific value.

TABLE XXXVI.

Gas Used.—Coal Gas and Blue Water Gas (B.W.G.=13.0% of Mixture). Gas Mixture "B" in Table XXXIV.

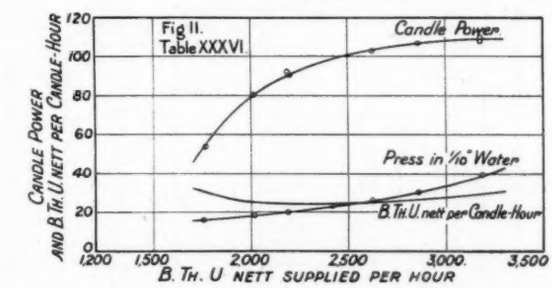
Calorific Value { 572 B.Th.U. gross } per c. ft. at 60° F.
{ 516 ,, nett } and 30" wet.

Sp. Gr.—0.45.

See also fig. 11.

B.Th.U. nett. Supplied per Hour.	Cu. Ft. Gas per Hour.	Candle Power.	Candles per Cu.Ft.	B.Th.U. nett per Candle Hour.	Candle power per 1000 B.Th.U. nett.	Nipple press "tenths" Water Gauge.
1800	3.50	59.5	17.0	30.4	32.9	16.5
1900	3.69	71.0	19.25	26.8	37.3	17
2000	3.88	79.4	20.43	25.2	39.7	18
2100	4.07	86.0	21.14	24.4	41.0	19
*2200	4.27	91.2	21.40	24.1	41.5	20
2300	4.47	94.7	21.21	24.3	41.2	21
2400	4.66	98.0	21.04	24.5	40.8	23
2500	4.85	100.7	20.80	24.8	40.3	24.5
2600	5.04	103.0	20.44	25.2	39.7	26
2700	5.24	104.7	20.00	25.8	38.8	27.5
2800	5.43	106.0	19.55	26.4	37.9	29
2900	5.63	107.3	19.08	27.1	36.9	31
3000	5.82	108.0	18.56	27.6	36.2	33
3100	6.02	108.6	18.05	28.6	35.0	36
3200	6.21	109.0	17.56	29.4	34.0	39
3300	6.40	109.3	17.10	30.2	33.1	42

* Maximum Efficiency.



At 1800 B.Th.U. net per hour the mantle was properly heated for two-thirds its height, and the air-ports were nearly closed. It was necessary to open the air-ports fully from 2600 B.Th.U. per hour and upwards. The brilliancy of the mantle was good throughout. Throughout this set of tests (until 2500 B.Th.U. net per hour was exceeded) there was some difficulty in completely filling the mantle with flame.

There is no marked difference in manipulation of the burner between this mixture and the previous mixture, except that it is slightly more sensitive to air adjustment.

REVIEW OF RESULTS OF TABLES XXXIV TO XXXIX.

The results just reported, all obtained on the same burner, may now be reviewed, having regard to the fact that the burner was in no way altered to meet the requirements of any particular grade of gas—a consideration likely to be of greater importance as the grade departs further from the normal. Interest centres around the attainable illuminating power and thermal efficiency for each gas mixture.

TABLE XXXVII.

Gas Used.—Coal Gas + Blue Water Gas.
B.W.G.=23.8% of Mixture. Gas Mixture "C" in Table XXXIV.

Calorific Value. {541 B.Th.U. gross } per c. ft. at
{486 „ nett } 60° F. 30" wet.

Sp. Gr.— 0.46

See also fig. 12.

B.Th.U. Nett. Supplied per Hour.	C.Ft. Gas per Hour.	Candle Power.	Candles per C.Ft.	B.Th.U. Nett per Candle Hour.	Candle Power per 1000 B.Th.U. Nett.	Nipple Press. "tenths" Water Gauge.
1800	3.71	58.3	15.71	30.9	32.4	16
1900	3.92	67.0	17.10	28.4	35.2	17
2000	4.12	74.0	17.97	27.1	36.9	18
2100	4.32	79.8	18.48	26.3	38.0	19
*2200	4.53	84.5	18.65	26.1	38.3	20
2300	4.73	88.3	18.66	26.1	38.3	21.5
2400	4.94	91.7	18.57	26.2	38.2	23
2500	5.15	94.5	18.37	26.5	37.7	25
2600	5.35	97.0	18.12	26.8	37.3	27.5
2700	5.55	99.3	17.92	27.1	36.9	30
2800	5.76	101.8	17.69	27.5	36.4	33
2900	5.97	104.0	17.45	27.9	35.8	37
3000	6.17	106.7	17.30	28.1	35.6	41

* Maximum efficiency.

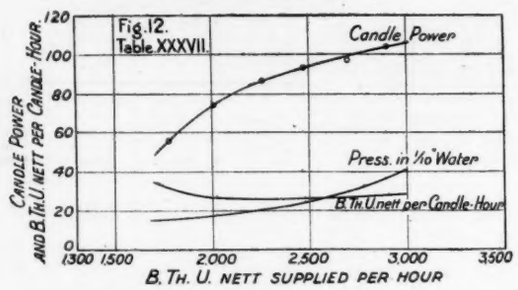


Fig. 12.
Table XXXVII.
Candle Power
Press. in 1/10" Water
B.Th.U. nett per Candle-Hour
CANDLE POWER AND B.Th.U. NETT PER CANDLE-HOUR
B. TH. U. NETT SUPPLIED PER HOUR

TABLE XXXVIII.

Gas Used.—Coal Gas + Blue Water Gas.
B.W.G.=35.5% of Mixture. Gas Mixture "D" in Table XXXIV.

Calorific Value. {506 B.Th.U. gross } per c. ft. at
{455 „ nett, } 60° F. 30" wet.

Specific Gravity—0.47

See also fig. 13.

B.Th.U. Nett supplied per Hour	Cu.Ft. Gas per hour	Candle Power.	Candle per Cu.Ft.	B.Th.U. Nett per Candle Hour.	Candle Power per 1000 B.Th.U. Nett.	Nipple Press. "tenths" Water Gauge.
1600	3.52	48.0	13.64	33.3	30.0	12.5
1700	3.74	57.0	15.23	29.8	33.6	14
1800	3.96	64.0	16.16	28.1	35.6	15.5
1900	4.18	69.7	16.69	27.2	36.8	17
*2000	4.40	74.0	16.83	27.0	37.0	19
2100	4.62	77.5	16.77	27.1	36.9	21
2200	4.85	80.6	16.62	27.3	36.6	23
2300	5.07	83.2	16.44	27.6	36.2	25
2400	5.28	85.7	16.22	28.0	35.7	27
2500	5.51	88.1	15.97	28.8	35.2	29
2600	5.73	90.3	15.77	28.4	34.7	31
2700	5.94	92.2	15.54	29.2	34.2	34
2800	6.17	94.1	15.27	29.7	33.8	37
2900	6.38	96.0	15.04	30.2	33.1	40
3000	6.61	97.7	14.72	30.8	32.5	43
3100	6.83	99.1	14.51	31.3	31.9	46
3200	7.05	100.7	14.29	31.8	31.4	50

* Maximum efficiency.

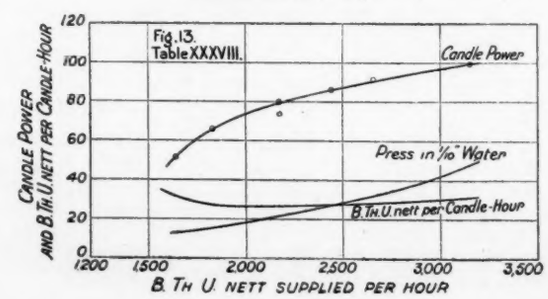


Fig. 13.
Table XXXVIII.
Candle Power
Press. in 1/10" Water
B.Th.U. nett per Candle-Hour
CANDLE POWER AND B.Th.U. NETT PER CANDLE-HOUR
B. TH U. NETT SUPPLIED PER HOUR

TABLE XXXIX.

Gas Used—Coal Gas + Blue Water Gas.
B.W.G.=51.8% of Mixture. Gas Mixture "E" in Table XXXIV.

Calorific Value. {453 B.Th.U. gross } per c. ft. at
{409 „ nett } 60° F. 30" wet.

Specific Gravity—0.49

See also fig. 14.

B.Th.U. Nett. supplied per Hour.	Cu. Ft. Gas per hour.	Candle Power.	Candles per Cu. Ft.	B.Th.U. Nett per Candle Hour.	Candle Power per 1000 B.Th.U. Nett.	Nipple Press. "tenths" Water Gauge.
1700	4.17	52.0	12.48	32.8	30.5	18
1800	4.41	58.4	13.22	30.9	32.4	19.5
*1900	4.55	63.8	14.00	29.2	34.2	21
2000	4.89	68.2	14.00	29.2	34.2	23
2100	5.14	72.1	14.02	29.2	34.2	25
*2200	5.38	75.7	14.08	29.0	34.5	27
2300	5.63	78.7	13.99	29.2	34.2	29
2400	5.87	81.4	13.87	29.5	33.9	32
2500	6.12	83.9	13.70	29.9	33.4	35
2600	6.36	85.9	13.51	30.2	33.1	38
2700	6.61	87.8	13.29	30.8	32.5	42
2800	6.85	89.5	13.08	31.3	31.9	46
2900	7.09	91.0	12.85	31.8	31.4	52
3000	7.34	92.6	12.62	32.4	30.9	58

* Maximum efficiency.

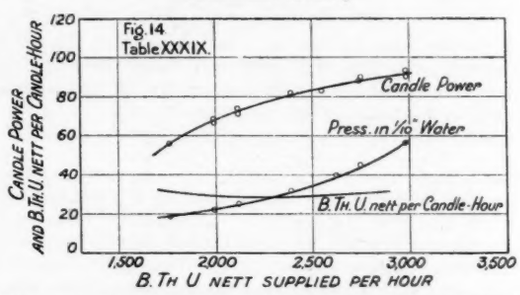
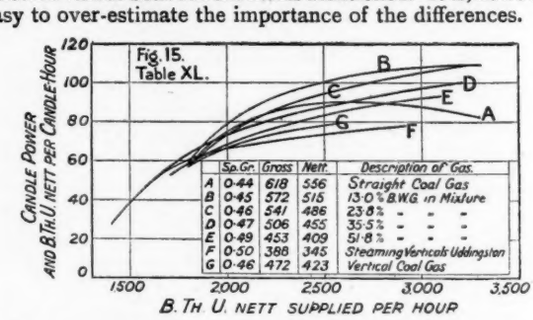


Fig. 14
Table XXXIX.
Candle Power
Press. in 1/10" Water
B.Th.U. nett per Candle-Hour
CANDLE POWER AND B.Th.U. NETT PER CANDLE-HOUR
B. TH U NETT SUPPLIED PER HOUR

For ease of comparison, the candle power curves have been drawn on a common diagram in fig. 15, and selected data have been set out in Table XL.

At the outset it will be noted that the curves branch outwards from what is roughly speaking a common "stem" between 1600 and 1800 B.Th.U. net per hour, and at 3000 B.Th.U. net per hour there is a difference in illuminating power of (79 to 108) 29 candles for the same rate of heat supply, between the highest and lowest result.

With two exceptions, both of which can be explained (Curves A and G), the curves lie in the order of their calorific values between the limits mentioned. It is, however, easy to over-estimate the importance of the differences.



	Sp.Gr.	Gross	Nett.	Description of Gas.
A	0·44	618	556	Straight Coal Gas
B	0·45	572	515	13·0% B.W.G. in Mixture
C	0·46	541	486	23·8% - - -
D	0·47	506	455	35·5% - - -
E	0·49	453	409	51·8% - - -
F	0·50	388	345	Steaming Vertical: Uddingston
G	0·46	472	423	Vertical Coal Gas

From consideration of published results, makers' catalogues, and pre-war practice, the impression is gained that the "C" size upright mantle was intended to deal with 3·5 to 4 c.ft. of gas per hour of a calorific value between 540 and 560 B.Th.U. net per c.ft.—*i.e.*, roughly speaking, 1900 to 2200 B.Th.U. net per hour.

Under these conditions an ordinary upright burner* was expected to yield about 20 candles per cubic foot, corresponding with 27 to 28 B.Th.U. net per candle-hour and a total illuminating power of 80 candles. These results have been reached in the present tests, and in some cases surpassed.

It will thus be seen that 3000 B.Th.U. net per hour represents a heat supply approximately 50 p.ct. in excess of

* Higher results have been claimed for special burners such as the No. 4 burner of our report, which in the tests on the Uddingston gas yielded results which tend to support the claim.

TABLE XL.

Calorific Value Gross.	618		572		541		506		453		472		385	
" " Nett.	556		516		486		455		409		423		347	
Specific Gravity:	0.44		0.45		0.46		0.47		0.49		0.46		0.50	
B.T.U. Nett. Hour Supplied.	‡I.P.	I.P. per 1000 B.T.U. Nett.	I.P.	I.P. per 1000 B.T.U. Nett.	I.P.	I.P. per 1000 B.T.U. Nett.	I.P.	I.P. per 1000 B.T.U. Nett.	I.P.	I.P. per 1000 B.T.U. Nett.	I.P.	I.P. per 1000 B.T.U. Nett.	I.P.	I.P. per 1000 B.T.U. Nett.
1800	57.0	31.6	59.5	32.9	58.3	32.4	64.0	35.6	58.4	32.4	57.0	31.6	61.2	34.0
1900	66.0	34.7	71.0	37.3	67.0	35.2	69.7	36.8	63.8	34.2	61.8	32.5	64.5	33.9
2000	73.6	36.8	79.4	39.7	74.0	36.9	74.0	37.0	68.2	34.2	66.0	32.9	66.4	33.1
2100	79.8	38.0	86.0	41.0	79.8	38.0	77.5	36.9	72.1	34.2	69.6	33.1	68.2	32.5
2200 *	84.0	38.2	91.2	41.5	84.5	38.3	80.6	36.6	75.7	34.5	73.0	33.1	70.0	31.8
2300	87.3	37.9	94.7	41.2	88.3	38.3	83.2	36.2	78.7	34.2	75.9	33.0	71.4	31.1
2400	89.0	37.2	98.0	40.8	91.7	38.2	85.7	35.7	81.4	33.9	78.0	32.5	72.9	30.4
2500	90.1	36.0	100.7	40.3	94.5	37.7	88.1	35.2	83.9	33.4	79.0	31.6	74.6	29.9
2600	90.5	34.7	103.0	39.7	97.0	37.3	90.3	34.7	85.9	33.1	79.0	30.3	75.2	28.9
2700	90.5	33.4	104.7	38.8	99.8	36.9	92.2	34.2	87.8	32.5	—	—	76.5	28.3
2800	90.0	32.1	106.0	37.9	101.8	36.4	94.1	33.8	89.5	31.9	—	—	77.5	27.6
2900	89.0	30.7	107.3	36.9	104.0	35.8	96.0	33.1	91.0	31.4	—	—	78.3	27.0
3000	88.0	29.4	108.0	36.2	106.7	35.6	97.7	32.5	92.6	30.9	—	—	—	—
% of B.W.G. in mixture.	Nil.		13.0%		23.8%		35.5%		51.8%		Uddingston without Steaming.		Uddingston Steaming.	
	Ex Table 35		Ex Table 36		Ex Table 37		Ex Table 38		Ex Table 39		Ex Table ?		Ex Table 25	

* Maximum Efficiency. ‡ I.P. Illuminating Power.

the normal supply for the burner, and the use of such rates of heat supply is only justified in attempting to exaggerate differences and elucidate certain points in connection with gas utilization. The differences so obtained are not, therefore, those of ordinary use.

If the heat consumption is reduced to the normal 2200 B.Th.U. net per hour the differences are less important (70 min., 92 max., diff. 22 candle power). A little below this point the curves converge rapidly, and between 1800 and 1900 B.Th.U. net per hour it is questionable whether isolated tests made upon the different grades of gas in succession would show any decisive differences.

Moreover, it is of the utmost importance to bear in mind that the burner, as used for the tests, without alteration, was one in common use, and therefore presumably of a design and construction gradually evolved to meet the requirements of a gas of normal calorific value.

From our experiments it is plain that completely satisfactory comparison of the different gases can only be made when each is permitted to exercise its maximum duty in an appliance properly adapted to its use.

The results of the experiments made at Uddingston form an instructive commentary on this factor in the situation, indicating as they do the extent of the benefits resulting from a simple enlargement of the nipple orifice on the one hand and a careful choice of burner on the other.

REPORT OF THE REFRACTORY MATERIALS COMMITTEE.

ON THE CRUSHING STRENGTH OF FIREBRICKS.

By W. EMERY and J. W. MELLOR.

The crushing strengths of firebricks are usually so much higher than is required in practice that this property is usually ignored. Apart from the direct utilitarian aspect of this quality, a comparison of the crushing strength of firebricks gives an idea of the internal strength of the brick and how the binding agent is doing its work.

In this work, bricks were made from the clays whose analysis, squatting temperature, surface factors, and grog size are indicated in Table I. The term "fine grog" refers to that which passes 16's lawn; "medium grog" stays on 16's and passes 8's lawn; "coarse grog" stays on 8's and passes 4's lawn.

TABLE I.

ANALYSES OF MATERIALS.

Laboratory Mark.	O	D	V	S	Z
SiO_2	53·84	61·88	55·90	49·55	51·24
TiO_2	1·32	1·14	1·47	1·67	1·39
Al_2O_3	25·73	22·37	27·74	30·30	28·06
Fe_2O_3	5·25	3·00	2·06	1·56	1·88
MgO	0·83	0·44	0·40	0·69	0·30
CaO	0·54	0·32	0·30	0·30	0·40
K_2O	1·48	1·42	1·31	1·45	1·20
Na_2O	0·27	0·36	0·49	0·49	0·24
Loss	11·04	8·72	10·79	14·34	15·74
Surface factor	1138	388	780	414	412
Squatting temperature	20–26	26	31	31	31

TABLE II.

CRUSHING TESTS.

Laboratory Mark.	1 Clay. 1 Fine Grog.	1 Clay. 1 Medium Grog.	1 Clay. 1 Coarse Grog.	3 Clay. 2 Fine Grog.	3 Clay. 2 Medium Grog.	3 Clay. 2 Coarse Grog.	2 Clay. 1 Fine Grog.	2 Clay. 1 Medium Grog.	2 Clay. 1 Coarse Grog.
S	949	643	557	990	678	572	1081	806	694
Sa	100	67·7	58·7	100	68·5	57·7	100	74·6	64·2
D	1137	890	808	2028	885	875	2636	1258	1025
Da	100	78·3	71·1	100	43·6	43·1	100	47·7	38·9
O	4451	1933	1693	5884	2302	1905	5512*	2487	1983
Oa	100	43·4	38·0	100	39·1	32·4	100	45·1	35·9
Z	1128	711	688	1005	994	874	1337	1198	888
Za	100	63·0	61·0	100	98·9	87·0	100	89·6	66·4

* Over-fired.

The series of crushing tests indicated in Table II. were made on firebricks by the method indicated in the standard specification. S, D, O, Z represent the observed crushing strengths in pounds per square inch; Sa, Da, Oa, Za respectively represent the same data showing the percentage effect with the grog variations.

The results in Table III. show the results of tests on bricks cut into two halves; the V_1 series were tested with the load on the 9 in. by $2\frac{1}{2}$ in. face; while the V_2 series had the load applied on the $4\frac{1}{2}$ in. face. The V_1a and V_2a series represent the data reduced to percentages.

TABLE III.

Laboratory Mark.	A 1. 1 Clay. 1 Fine Grog.	A 2. 1 Clay. 1 Medium Grog.	A 3. 1 Clay. 1 Coarse Grog.	B 1. 3 Clay. 2 Fine Grog.	B 2. 3 Clay. 2 Medium Grog.	B 3. 3 Clay. 2 Coarse Grog.	A 4. 2 Clay. 1 Fine Grog.	A 5. 2 Clay. 1 Medium Grog.	A 6. 2 Clay. 1 Coarse Grog.
V_1	1745	1289	1052	1940	1378	1184	2073	1484	1239
V_1a	100	73·9	60·3	100	71·0	61·0	100	71·6	59 8
V_2	3047	2328	2168	3333	2992	2546	3552	3166	2819
V_2a	100	76·4	71·1	100	89·8	76·4	100	89·1	79·3

The results show that the crushing strength is reduced by increasing the grain-size of the grog when the proportion of grog is constant; and also by increasing the proportion of grog when the grain-size is constant. Further, bricks tested with the load applied to the $4\frac{1}{2}$ in. face give higher crushing strength than when the load is applied as directed in the standard specification—*i.e.*, on the narrow side.

There are not yet sufficient data available to enable any conclusion to be drawn respecting a possible relation between the so-called fusion temperature of the clay and the crushing strength of the cold bricks. There is probably a close connection between the temperature coefficient of the vitrification and the crushing strength; and it is further probable that the crushing strength reaches a maximum during the firing of the brick, and that the strength gradually deteriorates* when the bricks are in use. It does not follow that the crushing strength of the newly-fired brick is at its maximum.

In an attempt to follow the deterioration of firebricks heated for periods of eight days, during three of which the temperatures were in the neighbourhood of Cone 9 (1280° C.), the crushing strength of a typical fireclay brick supplied by the manufacture rose from 2300 lbs. per sq. in. to a maximum on the tenth firing of 2875 lbs. per sq. in. The strength then gradually fell to 2700 lbs. per sq. in. on the fifteenth firing, and to 2150 lbs. per sq. in. on the nineteenth firing. This shows that the firebricks turned out by the manufacturer had not attained their maximum mechanical strength. When the brick was afterwards reheated, the mechanical strength increased, owing to the continuation of the work of vitrification which is supposed to be nearly completed in the burning of the brick. It is the continuation of these changes which gives rise to the so-called after-contraction (or after-expansion) of a firebrick.

In another fine-grained silica brick, the crushing strength fell from 2700 lbs. per sq. in. to 2325 lbs. per sq. in. on the fifth firing, and to 2050 lbs. per sq. in. on the fifteenth firing. Another medium-grained silica brick fell from 2200 lbs. per sq. in. to 1050 lbs. per sq. in. on the fifth firing. Another fifteen firings produced no perceptible change in the strength of the brick. Three other kinds of firebrick underwent no change which was perceptible outside the limits of experimental error.

* J. W. Mellor, *Collected Papers: Clay and Pottery Industries*, London, 312, 1914.

APPENDIX.

The contractions of the bricks made with the hard-fired grog are indicated in the subjoined Table IV. The bricks were made as indicated in the report of refractoriness under load. The firing of the bricks at Cone 1 was conducted in an ordinary brick-kiln occupying approximately fifty hours; and the same bricks were again fired at Cone 10 in another kiln occupying about the same time.

The most interesting point about these contractions is their smallness. It seems as if the grog has been so thoroughly shrunk that it fixes itself as a rigid framework which does not move with the contracting clay. This is a most interesting point and should be followed up more closely.

HEAT CONDUCTIVITY.

By C. EDWARDS, A. RIGBY, and J. W. MELLOR.

[Messrs. Edwards and Rigby had not finished the calculations in time for this meeting; so these and the conclusions will be added later.—J. W. M.]

The relation between the thermal conductivity of refractory materials and porosity is an important point in connection with the manufacture of saggars, muffles, quarries or muffles, and gas-retorts where a high conductivity is desirable. It has been abundantly proved that the thermal conductivity of insulation materials at ordinary temperatures is greater the less porous the materials; and it has been assumed that the results apply also at high temperatures. Hence it is inferred that a low porosity is desirable in order to ensure a rapid passage of heat through the walls of the muffle or retort. In a lecture at Manchester in 1914 one of us ventured to take a diametrically opposite view, by showing that the transmission of heat by radiation and convection has not been taken into account. In the published report it was stated:

We must clearly distinguish between high and low temperature thermal conductivity. When it is stated that a high porosity is

TABLE IV.

PERCENTAGE CONTRACTIONS.

		A 1.	A 2.	A 3.	B 1.	B 2.	B 3.	A 4.	A 5.	A 6.
D.	Contraction at K 1	2·20	1·40	0·75	2·45	1·29	1·12	1·78	1·29	1·20
	After contraction at K 10	0·38	0·30	0·29	0·50	0·37	0·42	0·55	0·46	0·46
	Total ,, ,, K 10	2·58	1·70	1·04	2·95	1·66	1·54	2·33	1·75	1·66
S.	Contraction at K 1	0·8	0·8	0·66	0·87	0·75	0·66	1·00	1·00	0·95
	After contraction at K 10	0·2	0·2	0·17	0·25	0·30	0·33	0·37	0·25	0·21
	Total ,, ,, K 10	1·00	1·00	0·83	0·12	1·05	1·00	1·37	1·25	1·16
O.	Contraction at K 1	2·9	2·0	1·30	3·28	2·57	2·35	3·32	2·73	2·32
	After contraction at K 10	0·1	0·46	0·33	0·34	0·47	0·35	0·25	0·21	0·17
	Total ,, ,, K 10	3·0	2·46	1·63	3·62	3·04	2·70	3·57	2·94	2·94
V.	Contraction at K 1	2 35	1·87	1·30	2·90	2·57	2·07	3·07	2·70	2·44
	After contraction at K 10	0·25	0 30	0·20	0·30	0·38	0·30	0·34	0·38	0 30
	Total ,, ,, K 10	2·60	2·17	1 50	3·20	2 95	2·37	3·41	3·08	2·74
Z.	Contraction at K 1	0·8	0·9	0·38	0·87	1·09	1·12	2·40	1·57	1·08
	After contraction at K 10	0·2	0·1	0·04	0·21	0·08	0 09	0·17	0·21	0·12
	Total ,, ,, K 10	1·0	1·0	0·42	1·08	1·16	1·21	2·57	1·78	1·20

inimical to the flow of heat through the walls of a retort, the effect of the radiation of heat across the pore space is forgotten. It is usually considered that the amount of heat which is conducted through a slab of unit thickness in unit time is k (T-T_o) calories per unit surface, when T represents the absolute temperature of the hot side, and T_o that of the cold side of the slab. The amount of heat exchanged by radiation between a hot and a cold surface in unit time is k_1 (T^4-T_o^4) calories per unit surface. For fire-clay the value of k is nearly 0·0025 and of k_1 nearly 8×10^{-11}. Consequently, at a little below dull-red heat the amount of heat radiated across an air space from unit surface in unit time will be equal to that which would be conducted through a fire-clay slab of unit thickness in the same time. The insulating properties of air thus break down in the vicinity of dull redness, and at higher temperatures the air spaces behave as if air were a good conductor of heat. Unless something has been overlooked, it is therefore inferred that a high porosity favours the passage of heat through the walls of a gas-retort at temperatures exceeding dull redness.

According to J. Stefan's rule, the quantity of heat Q_1 radiated by a body is proportional to the fourth power of the absolute temperature, or

$$Q_1 = k_1 T^4$$

where k_1 is the radiation constant, which L. Graetz found to be nearly $1{\cdot}086 \times 10^{-12}$. Consequently, for the transmission of a small quantity of heat dQ, when the temperature rises a small quantity dT

$$dQ_1 = 4k_1 T^3 dT \text{ cals. per sq. cm. per second.}$$

Again, the quantity of heat dQ_2 conducted across x cm. of the same space is proportional to the difference of temperature dT between the two boundary surfaces, or

$$dQ_2 = \frac{k_1}{x} dT \text{ cals. per sq. cm. per second.}$$

where k_1 is the conductivity constant of the solid. When the amount of heat transmitted by radiation and conduction across the space x is equal to the quantity transmitted through the solid by conduction

$$\frac{dQ}{dT^1} = \frac{dQ}{dT^2}$$

or

$$4k_1 T^3 = \frac{k}{x}; \text{ or, } T = \sqrt[3]{\frac{k}{4k_1 x}}$$

If the values of the conductivity constant be $k = 2{\cdot}5 \times 10^{-3}$, and the radiation constant $k_1 = 1{\cdot}26 \times 10^{-12}$, the inversion temperature, or the temperature at which the insulating quality of air breaks down, so to speak, will be inversely proportional to the linear dimensions of the pore in the direction of the flow of heat, or

$$T = 794 \times \frac{1}{x}$$

The idea is illustrated in fig. 1, showing the relation between the width of the pore and the absolute inversion temperature at which the heat transmitted by radiation across a a pore gap begins to exceed that transmitted by conduction through the solid. The size of the pores in porous refractories is, of course, variable. The largest are certainly over 0·5 cm. If the dimensions be $x = 0{\cdot}5$ cm., $T = 997°$K, or 724°C; if $x = 0{\cdot}1$ cm., $T = 1706°$K, or 1433°C; and if $x = 0{\cdot}01$ cm., $T = 3673°$K, or 3400°C. Consequently, just over a dull red heat, for big pores, the porous material is a better conductor than the solid, and for pores much less than 0·1 cm. the inversion temperature is outside the range of ordinary furnace conditions.

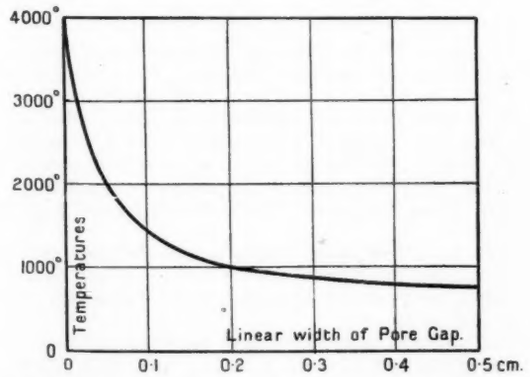


Fig. 1. Relation between the Inversion Temperature and Pore Gap.

It is not difficult to see the physical meaning of these statements. The speed of radiation at first sight appears to be much faster than conductivity; but this is more than compensated by the small amount carried across the air space. The shorter the distance traversed, the less chance has radiation (relatively small quantity carried very quickly) to gain on conductivity (relatively large quantity carried slowly).

In the above computation (*a*) the conductivity of the air is neglected, and it is assumed (*b*) that the conductivity of the solid does not vary with the temperature, and (*c*) that no heat is conveyed across the space by convection. But, in a closed pore, when the temperature of one face is greater than the other, there must be a continual up-current on the hot face and a downward current on the cool face—a miniature trade wind so to speak, blowing the faster the greater the difference of temperature between the two faces. A significant proportion of heat must be so carried across the pore gap. Since the amount carried in this way is quite indefinite, the above calculations are stultified, and direct observation is necessary.

Ordinary 9 in. bricks were made with varying proportions of grog, size of grog constant; and with varying sizes of grog, proportion constant.

Proportion.	Grog Passed $\frac{1}{10}$ in. Lawn.						Grog Stayed on $\frac{1}{10}$ in. Lawn and Passed $\frac{1}{8}$ in. Lawn.						Grog Stayed on $\frac{1}{8}$ in. Lawn Passed $\frac{1}{4}$ in. Lawn.					
	A_1	B_1	C_1	D_1	E_1	F_1	A_2	B_2	C_2	D_2	E_2	F_2	A_3	B_3	C_3	D_3	E_3	F_3
Clay	5	6	7	8	9	10	5	6	7	8	9	10	5	6	7	8	9	10
Grog	5	4	3	2	1	0	5	4	3	2	1	0	5	4	3	2	1	0

The grog was fired to Cone 10; so also were the bricks. The bricks were made with three holes penetrating to different depths, as illustrated in fig. 2. These holes served

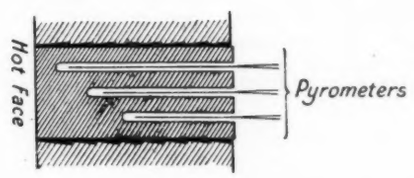


Fig. 2.

for the introduction of thermocouples, which were standardized and connected with the recorder. This gave a continuous record of the temperature of the bricks. The analysis of the clay (dried at 109°) from which the bricks and grog were made is:

Silica (SiO_2)	61·93
Titanic oxide (TiO_2)	1·13
Alumina (Al_2O_3)	23·96
Ferric oxide (Fe_2O_3)	1·31
Magnesia (MgO)	0·38
Lime (CaO)	0·18
Potash (K_2O)	0·56
Soda (Na_2O)	0·26
Loss when calcined over 109° C.	10·15

The bricks were built into a gas-fired furnace arranged as illustrated in fig. 2; so that the face temperature of the brick could be read from time to time with a Féry pyrometer. The heating was continued until the curves showed that the temperatures were all in equilibrium. Cooling curves were also taken. The time occupied by a complete run varied from 18 to 20 hours. The bricks were made by Mr. J. C. Green, at B. Gibbons' Dibdale works (Dudley) before the war, and the subsequent measurements had to be discontinued when the war broke out.

The first attempt was directed to the computation of the

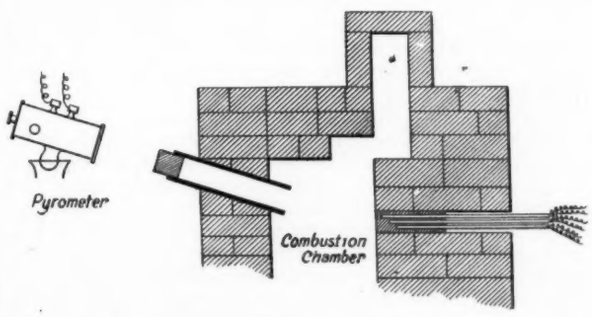


Fig. 3.

conductivities from the heating-up curves. Fourier's standard equation for the linear flow of heat in one direction is:

$$\frac{d^2\theta}{dx^2} = \frac{S}{a}\frac{d\theta}{dt}$$

Where θ is the temperature of a plane at right angles to the flow of heat, and x is the distance of another plane parallel to the former; t represents time; S denotes the thermal capacity of unit volume of the substance; and a is a constant denoting the amount of heat that flows per second through unit area when the temperature gradient is unity. Lord Kelvin wrote $s/a = \kappa$, and called κ the diffusivity of the substance. Fourier's equation then becomes:

$$\frac{d^2\theta}{dx^2} = \kappa\frac{d\theta}{dt}.$$

The limiting conditions are $\theta = \theta_0$ when $x = 0$, and $\theta = 0$ when $t = 0$; and the solution of the equation is then:

$$\theta = \theta_0\left(1 - \frac{2}{\sqrt{\pi}}\int^{\frac{x}{\sqrt{\kappa t}}} e^{-\beta^2}d\beta\right).$$

When $\beta = -\frac{1}{2}x/\sqrt{\kappa t}$. Expanding the integral in series

$$\theta = \theta_0 - \frac{2\theta_0}{\sqrt{\pi}}\left(\frac{x}{2\sqrt{\kappa t}} - \frac{x^3}{3(2\sqrt{\kappa t})^3} + \ldots\right)$$

from which the diffusivity κ can be calculated, and hence also the conductivity from the known values of specific heat at elevated temperatures. In applying this method with the apparatus available, the error of experiments was too large.

The cooling curves also enabled the conductivity to be computed by Forbes's well-known method. The temperature gradient $d\theta/dx$ was computed from the maximum readings of the thermocouples, and the distances of the thermocouples from the hot ends of the bricks. The value of $d\theta/dt$ was obtained from the cooling curve. Since—

$$\kappa\frac{d}{dx} = \int_x^\infty \frac{d\theta}{dt}dx$$

and the integral is evaluated from the area of the curve, κ can be computed. The conductivity is related to the specific heat C and specific gravity D by the relation:

$$\text{Conductivity} = \frac{\kappa C}{D}$$

The specific heat at a temperature θ is $C = 0{\cdot}193 + 0{\cdot}00006\theta$. The specific gravity of the solid is 2·5 at 15°. The calculations are as follows:

Distance of thermocouple from hot face	7·0	11·1	15·1 cm.
Temperature	710°	630°	450°
Rate of cooling, $d\theta/dt$	0·034°	0·031°	0·019° p.sec.
Temperature gradient dx/dt	15·6°	27·3°	55·0° per cm.
Product $d\theta/dt \times dx$	0·34	0·22	0·12
κ	0·223	0·008	0·002
Specific heat	0·233	0·230	0·222
Conductivity	0·0025	0·0007	0·0002

[Calculations and results to follow.]

LIFE OF GAS-METERS JOINT COMMITTEE.

INTERIM REPORT ON THE INTERNAL CORROSION OF MAINS AND SERVICES.

Corrosion of Meters.

In the paper entitled "Corrosion of Dry Gas-Meters," which was read at the autumn meeting (1918) of the Institution, attention was given chiefly to the action of certain compounds found to exist in the gas on meter leathers and valves, particularly during its period of manufacture under the stress of war conditions. Some reference was made to the corrosion of the metal parts of meters; and it was subsequently felt that this part of the subject should be amplified.

Dust in Mains.

At the same time, cases were brought to the notice of the Committee where dust had been found in mains, services, governors, and meters, by gas undertakings, the majority of whom were distributing gas under high pressure. The Committee inserted a paragraph in the Technical Journals inviting further information on the subject; and, in addition, a number of engineers were written to personally, with the object of obtaining particulars in respect to their working. Many of the cases were brought to light by an accumulation of dust in high-pressure governors. The Committee are indebted for information to Mr. H. J. Donkin, whose firm have had to bear the brunt of the trouble. Subsequently, however, it was found that similar experiences had occurred in systems of low-pressure distribution.

Oxide from Purifiers.

It was necessary at the outset to ascertain whether such dust, found in the distributing system, and composed chiefly of oxide of iron, was or was not oxide carried forward from the purifiers. This explanation has been put forward in several cases. For instance, at one works employing high-pressure distribution, the gas-compressor was connected in such a way as to exercise a pull direct on the purifiers, bye-passing—perhaps unintentionally—the gasholder. As evidence that the pull was exercised, it was reported that the cover of a purifier and the roof of a station meter were drawn in. In this case the mains and governors on the district were choked with dust; but no purification oxide was found in the station meter.

Collecting Samples.

From different parts of the country samples of deposits from mains and services have been received for analysis. None of these deposits contained peat as found in native bog ore, sawdust due to the use of artificial oxide, or alumina. Again, these deposits were found to contain much more ferric ferrocyanide (prussian blue) than is contained in purification oxide. Here is an instance:

Ferric ferrocyanide in purification oxide = 3·4 p.ct.
" " " deposit = 21·0 "

Deposits Due to Corrosion.

From the above it will appear that the dust deposits do not have their origin in purification oxide; and it therefore follows that corrosion of some sort has been taking place.

The Purifiers.

Having thus cleared away misapprehension as to the nature of the trouble, it remains to inquire as to the means and the conditions by reason of which it is brought about. The fact that many of the cases are reported as having occurred since oxide alone has been used in the purifiers is of interest for the following reasons:

1.—Absence of lime in purification accounts for the passing forward of the bulk of the hydrocyanic acid found in the gas.

2.—Small but varying amounts of this hydrocyanic acid would be extracted by oxide purification. Such action is hindered by revivification *in situ*, especially when an excessive proportion of air is passed into the purifiers

The Gas.

Another consideration is the impoverishment of modern gas in respect to its oily constituents, affecting the matter again in two ways:

1.—Condensation of watery content takes place more readily in mains and services owing to the lack of carrying power exercised by oily vapours.

2.—The distribution system lacks the protection afforded by the old-time natural lubricating properties of the gas.

Conditions of Corrosion.

With these changes in practice of recent years in respect to purification on the one hand, and the absence of enrichment of the gas on the other, we have a new condition of affairs in which are introduced both first and second class agents for corrosion. In pointing this out, it is not desired to raise undue alarm; for the issue is comparatively straightforward, and new conditions of gas making, which have come to stay, can be reasonably supplemented for the protection of plant.

Chemically, hydrocyanic acid is the primary agent of corrosion, the prejudicial effects of which are much increased by the presence of oxygen, while the carbon dioxide plays a lesser part.

Physically, no corrosion would be likely to take place except in the presence of moisture; and, as a matter of fact, it is at the "dew point" that corrosion mostly occurs.

High-Pressure Distribution.

The reason why there are more cases of corrosion with high-pressure than with low-pressure distribution probably arises from the deposition of moisture from the gas in the mains under the higher pressure. The gas enters the com-

pressor saturated with water vapour, and the operation of compression raises the temperature for the time being to a degree that makes its capacity for retaining the water vapour far exceed the effect of compression. When the gas cools down in the mains to its original temperature or below, the effect of the compression becomes operative in the amount of moisture condensed. In many cases the cylinders of the compressors are water-cooled; but this does not usually lower the temperature of the gas sufficiently to bring-down all the moisture before the gas enters the mains.

CONDENSATION BY COMPRESSION.

A suggestion has been made that in such cases the gas might be raised to a pressure exceeding by a few pounds that which is actually required for purposes of distribution, and while at this higher pressure, the gas should be cooled to its original temperature or lower, thus bringing-down the water vapour content in excess of that which pertains to the pressure and temperature in the condenser. Subsequently the gas is expanded into the mains at a lower pressure, and passes through the distribution system well below its saturation point. This should prevent any further deposition of moisture.

A TEST CASE.

To test the efficacy of this system, a visit has been made to a works where gas is compressed to 50 lbs. per square inch, cooled, and subsequently expanded into the mains at 5 lbs. only. All mains and services are laid without any fall and without receivers. No condensation takes place in the district, and no trouble has occurred either in the nature of corrosion or naphthalene deposit. This method is known as the "Helps System." The primary objects of the high compression are doubtless storage of gas under pressure, a reserve of pressure for emergencies, and certain advantages of intermittent pumping. But it is evident that consideration of the vapour content in the gas has also entered into the scheme. This provision for the removal of water from the gas probably has results beyond those originally anticipated; for the condensed water brings down with it certain salts which play a direct part in corrosion.

An analysis has been made of aqueous liquor taken from the compression tank, as follows:

	Grains Per Gallon.
Ammonium thiocyanate	31·0
,, ferrocyanide	15·0
,, sulphate	4·4
,, sulphide	1·6
Ferrous sulphate	1·3
Carbon dioxide	31·5

As the amount of condensation was equivalent to about 80 gallons per million cubic feet of gas compressed, some idea of the quantities of the corrosive salts removed from the gas may be gleaned.

LOW-PRESSURE DISTRIBUTION.

Some further remarks are called for in respect to low-pressure distribution. It may be remembered that, in the paper read before the special meeting of the Institution in October last, reference was made to the interaction of ammonia with carbon bisulphide, producing corrosive salts, even in the case of the undertakings which remove hydrocyanic acid from their gas. The elimination of ammonia, with consequent prevention of such indirect means of corrosion, is in normal times a matter of course for all gas undertakings; but cyanogen washing is the exception rather than the rule. The present investigation deals with undertakings where the removal of hydrocyanic acid is not carried out; and the conclusion therefore is either that this impurity should be removed or protection given to the internal surface of the distributing plant.

REMOVING CYANOGEN.

So far as the first alternative is concerned, it may be of interest here to mention that, in the presence of steam and incandescent coke, hydrocyanic acid is converted into ammonia. Thus:

$$HCN + OH_2 = NH_3 + CO$$

This reaction should be of considerable interest to those who contemplate the steaming of retorts.

It may be well to note, conversely, that ammonia in the absence of steam is converted into hydrocyanic acid by passing over red-hot coke. Thus:

$$NH_3 + C = HCN + 2H$$

SPRAYING THE MAINS.

If the alternative of protecting the mains and services be adopted, the remedy is the same as previously advocated for use with dry gas-meters—viz., lubrication by atomized paraffin oil. An illustration of the benefit derived from such lubrication is supplied in one of the first cases of corrosion brought to the notice of the Committee. The engineer reported that after spraying petroleum into the gas at the works the accumulation of black deposits on the district sensibly diminished until subsequently traces of petroleum were found in the mains at growing distances from the works, and in practically all syphons. The same remedy was applied to the high-pressure system; petroleum being introduced on the outlet of the compressors with similarly beneficial results.

TABLES OF AQUEOUS VAPOUR.

Reference is made to the accompanying tables of aqueous content which have been specially compiled for this report. Table I., giving the equivalent in gallons of water per million cubic feet of gas, shows at a glance the maximum quantity of water which can be held by the gas at given temperatures and pressures. By comparing the figures one with another, the amount of condensation which can take place either by reduction of temperature or increase of

TABLE I.—*Volume of Aqueous Vapour in Saturated Gas at Various Temperatures.*

(Absolute pressure 29·92 in. Mercury.)

Temperature. Degrees Fahr.	Aqueous Vapour P.Ct. of Total Volume of Wet Gas.	Temperature. Degrees Fahr.	Aqueous Vapour P.Ct. of Total Volume of Wet Gas.	Temperature. Degrees Fahr.	Aqueous Vapour P.Ct. of Total Volume of Wet Gas.
32	0·60	49	1·16	64	1·99
35	0·68	50	1·21	65	2·06
36	0·71	51	1·25	66	2·13
37	0·74	52	1·30	67	2·21
38	0·77	53	1·35	68	2·29
39	0·80	54	1·40	69	2·37
40	0·83	55	1·45	70	2·45
41	0·86	56	1·50	71	2·54
42	0·89	57	1·55	72	2·62
43	0·93	58	1·61	75	2·90
44	0·96	59	1·67	80	3·42
45	1·00	60	1·73	85	4·02
46	1·04	61	1·79	90	4·71
47	1·08	62	1·86	95	5·50
48	1·12	63	1·92	100	6·41

TABLE II.—*Aqueous Vapour in Saturated Gas at Various Temperatures and Gauge Pressures, expressed in Gallons of Water per Million Cubic Feet of Free Gas.*

Temp. Fahr.	0	1 Lb.	2 Lbs.	3 Lbs.	4 Lbs.	5 Lbs.	6 Lbs.	7 Lbs.	10 Lbs.	15 Lbs.	20 Lbs.	25 Lbs.	30 Lbs.	35 Lbs.	40 Lbs.	45 Lbs.	50 Lbs.
32	31	29	27	26	24	23	22	21	18	15	13	11	10	9	8	7½	7
35	35	33	31	29	27	26	25	24	21	17	15	13	11½	10	9½	8½	8
40	42	39	37	35	33	31	30	28	25	21	18	15	14	12	11	10	9½
45	50	47	44	41	39	37	36	34	30	25	21	18	16	15	13	12	11
50	60	56	53	50	47	45	43	41	36	30	25	22	20	18	16	15	14
55	71	66	63	59	56	53	50	48	42	35	30	26	23	21	19	18	16
60	84	79	74	70	66	63	60	57	50	42	36	31	28	25	23	21	19
62	90	84	79	75	71	67	64	61	54	45	38	33	30	27	24	22	20
65	99	93	88	83	78	74	70	67	59	49	42	37	33	29	27	25	23
70	117	110	103	97	92	87	83	79	70	58	50	43	38	35	31	29	27
75	137	128	121	114	108	103	98	93	82	68	58	51	45	41	37	34	31
80	160	150	141	133	126	120	114	109	95	79	68	59	53	47	43	39	36
85	187	175	164	155	147	139	133	127	111	93	79	69	61	55	50	46	43
90	216	202	191	180	170	162	154	147	129	107	92	80	71	64	58	53	49
95	250	234	220	207	197	186	178	170	149	124	106	93	82	74	67	62	57
100	288	270	254	239	226	215	205	196	172	143	122	107	95	85	78	71	66

pressure, or both, may be immediately obtained. It must, however, be borne in mind that these are saturation figures, and that when gas is raised in temperature it does not increase its vapour content unless in contact with water.

Table II. gives the percentages of aqueous vapour by volume, and may be useful for estimating the influence of condensation on unaccounted-for gas.

INVESTIGATION TO BE CONTINUED.

It is understood that this is only an interim report, and any conclusions that appear to have been drawn should be regarded as tentative. Further information on the subject is being collected by means of analyses and experiments. There has not yet been time and opportunity to ascertain the actual chemical formation of the deposits on the theory of corrosion.

SOME WAR EXPERIENCES OF BRITISH GAS UNDERTAKINGS.

By H. TOWNSEND, M.Inst.C.E., of Wakefield.*

When I was asked by the President and Council of the Institution to contribute to this meeting a record of the abnormal occurrences at gas-works caused by the terrible war which has raged during the past four years, I felt unable to resist the appeal, as I was so indiscreet as to make the suggestion myself at the meeting held in June, 1917. And I must compliment them upon having "made the punishment fit the crime" with such true Gilbertian humour. It has, however, caused me, I am afraid, to be a great nuisance to several of my brother managers, whose misfortune it was to be victims of Hun brutality. To them I offer my sincere apologies for the trouble I have given.

THE HARTLEPOOLS.

The first, and one of the most serious manifestations of German ruthlessness occurred on Wednesday, Dec. 16, 1914, when enemy battleships made a raid on the Hartlepools, Whitby, and Scarborough. Considerable damage and loss of life occurred in the two latter towns; but the gas-works escaped with comparative immunity. But the Hartlepools were not so fortunate. On that morning a German battle squadron of fast cruiser type, under cover of a thick haze which obscured the view seawards, bombarded the Hartlepools without warning, wrecked many buildings, and killed and maimed several hundred people. The three warships which took part were first-class battle cruisers "Von der Tann" (34 guns), "Seydlitz" (38 guns), and the "Blucher" (36 guns), having left Wilhelmshaven the previous night under cover of darkness to traverse the 330 miles journey across the North Sea. Distant booming was heard out at sea at 7.55 a.m., and warships dimly seen, apparently firing seawards. For a few minutes it was thought they were British battleships; but those watching were soon undeceived. The enemy were firing seawards to drive off a British light cruiser and two small destroyers, which were endeavouring, in the face of very great peril, to get within torpedo range. At 8.10 a.m., the leading enemy ship, the "Von der Tann," opened out her guns on the towns at a range of about 4000 yards; the other two ships following suit almost immediately. From then on, until 8.50 a.m., there was the most terrific roar of guns, broadside after broadside.

It was officially estimated that some 1500 shells were rained upon the two towns, and that 70 guns, of the total of 108, were brought at a time to bear. There were 112 civilians (men, women, and children), 9 military and 6 naval men killed, and 441 wounded persons taken to the hospitals, besides numbers of injured people who were treated as out-patients, and of whom we have no record. Some 145 houses were destroyed or badly damaged. But the total claims for damage to property amounted to about 1000—that of the Gas and Water Company being the largest individual claim. It must not be assumed the attacking ships escaped unscathed; for although the battery only then possessed two 6 in. guns, they gave a good account of themselves, and did considerable damage both to the "Von der Tann" and the "Blucher." The projectiles used by the enemy consisted of 3·4 in., 5·9 in., 8·2 in., and 11·2 in. shells. Twenty of the latter, filled with high explosives (T.N.T.), were found unexploded in soft ground.

A glance at the map [exhibited] will show the exposed position of the gas-works and the water pumping-station. The three gasholders are very prominent objects viewed from the sea, and must have afforded an excellent target for the enemy gunners. Within the first two or three minutes of the bombardment, shells were seen splashing into the timber docks adjoining the No. 1 gas-works, and scattering the timber stacks and pit-props in the timber yards in all directions. By 8.15 a shell had pierced the crown, near the centre, of holder No. 2—a two-lift column-guided holder, 140 ft. diameter, 750,000 c.ft. capacity, erected in 1879. At the time the holder was more than two-thirds full. The gas ignited at the rent made in the crown, and huge roaring flames shot up into the sky. In about fifteen minutes, the holder was down on the rest-stones; but the flames continued under the crown for over two hours before being finally extinguished. Three of the roof trusses were badly damaged, and 285 holes pierced in the sides and crown from within by the fragments from the bursting shell.

In the meantime, the smaller holder, No. 1—a three-lift spiral-guided one—had been struck by a shell, which made a jagged hole about 14 in. diameter where it entered one of the top row of plates just below a guide-rail, pierced the centre column upon which the crown rests when the holder is empty, and fragments then passed through the opposite side of the top-lift, making 140 holes. No one appears to have actually seen this holder on fire; but if it did catch fire, the flames were evidently extinguished by the descent of the holder into the tank, which would be quite possible, as there were no holes in the crown. Another shell struck the east end of the retort-house gable adjoining No. 1 holder; the fragments piercing the foul main and ascension pipes in the retort-house in various places. Another landed into the coke heap in the back yard on the north side of the retort-house named. The coke heap, 12 to 14 ft. thick, was scattered in all directions; but no damage was done.

No. 1 Retort-House Roof.—One of the iron principal backs and ventilator stanchions was shot away, and a number of iron purlins and slating—the fragments piercing the foul mains in the house in several places, and (rather curiously) cutting the coal elevator chain in two, causing all the buckets to collapse in a heap.

No. 2 Retort-House.—A shell here carried away the water tabling on the west gable and part of the roof and gable itself.

The foregoing are the principal items of damage at No. 1 gas-works; but there are innumerable indentations, many deep-set, in brick and stone walls about the works. The heat of the flames from the burning of No. 2 holder melted the flashing and lead gutters on the office roofs adjoining, and scorched the slates in places, so that they crumbled when handled, and had to be renewed. Glazing, of course, suffered tremendously; over 1100 panes being to replace.

It will be noted from the plan that the water-works pumping station is situated on the west side of No. 1 Gas-Works; the two sites being separated by the N.E. Railway Company's main coast line to Newcastle, and the main road between the Hartlepools. Here, in the first 15 to 20 minutes, a shell carried away the boundary wall at the south-east corner, killing a man who was passing. The newest of the engine-houses also had a direct hit from an easterly direction; the 11 in. by 4 in. members of the roof principals being treated like matchwood, and the pitch-pine ceiling destroyed. Later, as the bombarding ships moved round to the north, a shell from this direction carried away part of the boiler-house roof and the main high-pressure steam-pipe leading to the engine-houses. Another shell from the same direction pierced the north side of the large water tower, about 10 ft. or 12 ft. from the ground-line; the brick and stonework at the point struck being 2 ft. 6 in. thick. Adjoining the water-works are several cottages, the property of the Company, also the manager's house, and two semi-detached houses for certain other members of the staff. Unfortunately, one of the latter houses, occupied by the Company's accountant, was hit, and he received 32 wounds in the back and legs, and was laid up a considerable time. Eight of the Company's employees were injured—one so seriously that he died the following day.

As the attacking ships moved round to the north, the No. 2 Gas-Works and the water-works came more directly under fire, but the only serious damage done was to the three-lift column-guided holder, 150 ft. diameter, capacity 1½ million c.ft. This gasholder is a most prominent object looked at from the sea, and at the time was well up into

* A number of the photographs accompanying this paper were given at different times in the "JOURNAL" when reporting the accidents caused by enemy action.—ED. "G. J."

the third lift. It was struck by three shells; and from the fragments subsequently found, they were evidently of the largest type. The first shell struck the dip of the outer lift, and passed right through the middle lift cup, making a hole about 14 in. by 11 in. The second shell hit the top curb angle, immediately on the root of it, and then burst, sending the curb of the holder inwards for a whole bay, and ripping the top sheets open very near to the crown plate. The gas fired, buckling the sheets on the top and sides of holder, and twisting the whole of the inside framing about 2 ft.; one of the uprights in the outer row being broken and a number of the wood purlins destroyed by fire. Most of the top carriages were put out of their guides. The third shell hit one of the standards, about 20 ft. from the top, carrying part of the standard away. Two more of the standards and eight or nine of the girders were badly bent and much twisted by the heat from the fire which followed. Beyond glazing, and other damage of a minor character from splinters, the purifiers and other plant and buildings did not suffer very materially; the inference being that the enemy "went for" what was prominent in the towns. Well, the damage was there, and the situation—as unique as it was unwelcome—had to be faced. Two towns, and considerable outlying districts, with a population of at least 90,000, and extensive engineering works, were without gas. Before 10 a.m. the Company were in touch with two firms of specialists, who sent their men through in motor-cars by road. They immediately commenced to make temporary repairs to the No. 2 holder, which was the only one of the three at all possible to patch. With the assistance of the local steel works, six new plates for the crown were obtained; and all available hands were engaged at the same time repairing the other holes in the crown.

As soon as the crown was made good, men commenced to lift the holder with gas, and patch the holes in the sides as it rose—an unpleasant, difficult task, as it was necessary to make a large percentage of water gas in order to get the holder up quickly. A number of the men were temporarily laid-out from the ill-effects of it. By 6 o'clock on the Friday night (less than sixty hours after the bombardment), the gas supply was resumed; but it was some months before the other two holders were available. A number of people in the high part of the town were not without gas during the sixty hours the supply was cut off at the works. The water supply was also maintained, as, fortunately, the damage there was to buildings and not to plant, with the exception of the main steam-pipe referred to, which was replaced the same morning, before the water-tanks were exhausted.

The unwelcome visitation was not without its humorous side; for it was unusual to see the engineering staff in the drawing office without a window intact in the place, overcoats on, seeking out drawings to aid in procuring materials for reinstatement of the damage. What is to be remembered with gratitude is the whole-hearted desire of neighbours in the profession who proffered help, and came quickly upon the scene with that intent, and the loyalty and devotion of the Company's own staff and workmen.

Upon three occasions Zeppelins dropped bombs, doing a good deal of damage in the town; but, fortunately, the Company's property suffered nothing worse than broken windows. When the Zeppelin was brought down during November, 1916, it burst into flames about 250 yards south of No. 1 works, and at almost the same moment dropped several bombs, which knocked practically all the glass out of the windows facing south, including a good deal of stained glass in the offices. It sailed through the sky in flames in a long descending arc, and fell into the sea, where the fabric continued to burn on the surface for about half-an-hour. The last raid was on March 8, 1918, when the town was lighted up (having received no warning to take air-raid action). Several bombs were dropped near to No. 2 Gas-Works, breaking windows, and one bomb near No. 1 Gas-Works, the spindle and base plate of which ricochetted through No. 2 retort-house roof, but did no damage beyond breaking a few slates.

LONDON.—THE GAS LIGHT & COKE COMPANY.

The air-raids consisted roughly of two series. The first series comprises the Zeppelin raids. There were 32 warnings received, and during eight of these raids bombs were dropped in the Company's area of supply, damaging mains or services. During the first raids, the bombs dropped were mostly of the incendiary type. But explosive bombs were soon found to be more effective; and as the war proceeded these bombs were of progressively heavier type. With the exception of one raid on Oct. 19, 1917, which ended disastrously for the enemy, all the Zeppelin raids occurred between May 31, 1915, and June 15, 1917. The Company was very fortunate during this period; for though there were many narrow escapes, no main larger than 12 in. diameter was damaged, and in only one instance was the work of repair complicated by the escaping gas being fired. Perhaps the bomb resulting in the most troublesome repair was that which fell in Wellington Street, by the Lyceum Theatre, Oct. 13, 1915, which involved the bagging-off of four mains before the escaping gas, which had fired, could be stopped. During the last Zeppelin raid, Oct. 19, 1917, a bomb fell close to Piccadilly Circus, fracturing 12 in. and 10 in. mains lying close together.

The second series of raids were made by aeroplanes. There were 31 of these raids of which warning was received, and damage was done to mains and services on sixteen occasions. The first raid occurred on May 7, 1917, and the last on May 19, 1918. The most remarkable damage was as follows: During the night of Sept. 4, 1917, an aerial torpedo fell on the Embankment (by Cleopatra's Needle) on the pipe subway running from Westminster Bridge to the Mansion House. A large section of the crown of the subway was badly broken down; and a 30 in. pipe in a low-pressure main was completely shattered. Very fortunately the risk of damage to this particular main had been previously considered. The main had been shut-off by the insertion of a valve, and on this particular night was only fed by a 4 in. main controlled by a valve, which was shut as soon as possible after information had been received of the damage. There was a considerable accumulation of gas in the subway; and, in order to avoid risk of an explosion, the Embankment between Waterloo and Charing Cross Bridges was closed to all traffic until the pipe had been replaced. This was done by 1.30 p.m. the following day. The nose of the torpedo, weighing 6 lbs., was found in the shattered pipe. In the same subway is another 30 in. district main and a 36 in. high-pressure main, in addition to a number of electric cables, &c., which providentially were undamaged.

On Oct. 1, 1917, an anti-aircraft shell, which failed to explode, pierced one of three 21 in. mains lying under the wooden decking of the Grosvenor Road Railway Bridge. Subsequently the gas was exploded by a passing train—the wooden decking being blown up. The train was fortunately untouched. The fire melted the lead from joints in all three mains, and assumed very large proportions. The valves controlling the mains failed to hold; and the fire could only be extinguished by water-logging the pipes with the aid of the Fire Brigade. Considerable damage was done to the girders of the railway bridge, and to a granite facing of a pier supporting them.

On Jan. 28, 1918, a bomb fell on the carriageway of Wandsworth Road, outside the Vauxhall works of the South Metropolitan Gas Company. Under the paving, which was fortunately granite setts on an exceptionally hard concrete foundation, lie two 36 in. mains belonging to the Company; and a bomb fell between them. It failed to pierce the concrete foundation; but, nevertheless, the shock was sufficient to split a pipe in each main. The nature of the paving which saved the mains made the work of repair a somewhat difficult operation.

One chief source of anxiety were mains in subways. In the Company's area of supply are nine miles of subways, in which are fourteen miles of mains varying in diameter from 48 in. downwards. In most instances the mains in subways are connected to mains in roads crossing the subway; and wherever a main enters a subway there is a valve controlling it. There are forty such valves controlling the mains in the subway lying under Shaftesbury Avenue and Charing Cross Road; and it will be recognized that, in the event of damage to the mains, a dangerous situation would be likely to have arisen before all these valves could have been shut. In order to minimize the danger, only as many valves were left open as were necessary to maintain an adequate supply of gas to all the consumers affected. For instance, of the forty valves above mentioned it was found possible to close all excepting six. Mains over railway bridges were also sources of danger; and where controlling valves were not already in existence, they were put in.

The organization for dealing promptly and effectively with damage developed as the raids became of increasing severity. At the main office of the department, a special telephone line was installed, with a number known only to

the officers of the Company, the Police, and the Fire Brigade, and also a private line connected with the Fire Brigade Headquarters. It was not uncommon while a raid was in progress to receive six or more reports of escapes of gas within half-an-hour. Men were stationed at the various sub-offices of the Company during raids, and as many as ten motors were in readiness to carry men and tools wherever damage might happen to be reported.

EDINBURGH.

In connection with the Zeppelin raid over Edinburgh and Leith on the morning of April 3, 1916, a bomb was dropped in the Grassmarket, which landed on the pavement, tearing a great hole in it and damaging a 5 in. gas-main, which was just under the kerb. This main was broken and shattered in several places, and the ends left projecting up in the air. These ends were temporarily plugged with clay, and the gas was stopped by means of bladders at each end. Thereafter the pipe was capped with iron plugs until it could be relaid.

GORLESTON, GREAT YARMOUTH, BOMBARDMENT.

On the evening of April 24, 1916 (Easter Monday), at 9 p.m., notice was received to take air-raid action. During the night the noise of bombs dropping was heard, but none were dropped in the Company's area. At 3 a.m., the order to resume normal conditions was received. After this terrific gun firing started. Shells began whizzing through the air in pretty fast succession; and it was evident that the vicinity of the gas-works was getting its full share of attention at the hands of the enemy. This was accounted for by the fact that the works lay immediately behind a tall electric light shaft on the opposite side of the river which was being used as a target by the enemy. The shaft in question escaped; but, unfortunately, the gas-works received the shells, which were being fired from enemy Dreadnoughts, and were of the high explosive class. When firing ceased, it was at once decided to tackle the No. 1 Gasholder, which was hit in the crown, and into which all the make was going. The holder was of 60,000 c.ft. capacity, and had been struck in two places in the crown. A tongue of flame 12 ft. high was shooting upwards. Unfortunately, the shape of the punctures caused the flame to impinge upon the guide column, carriage, and wheel; and it was feared the holder might thus lock itself. A good number of employees were soon on the spot to render what help they could, and it was evident that the best method to extinguish the flame was to smother it. To this end, a supply of bricks and plastic clay was hoisted on to the crown of the holder, and the assistant to the Company, who had had some twenty-five years' retort patching to his credit, undertook the task. The holder was fast burning itself aground; and it was therefore a race against time to avoid this happening. Getting as near as the intense heat would permit, he first encompassed the extent of the damage, and, by carefully building inwards, was able to finally smother the flame with clay. This operation in all occupied about three-quarters of an hour, during which time the No. 3 Holder (200,000 c.ft. capacity) was also burning furiously.

Having extinguished the flame at the No. 1 Holder, No. 3 was taken in hand. In this case, a portion of a shell had hit the holder on the third sheet from the top, driving the piece of the plate inwards. The shell continued its path right through the holder, leaving on the opposite side at a distance of 4½ sheets from the top, or 1½ sheets lower than the point of entry. It was found when the holder was undergoing repairs that no internal damage had been done to the framing, &c. Gas was issuing from the hole on the inward path; but at the outward path it had fired. The intense heat had distorted the guide bracings, platform, and rail. By the time the holder was reached, the hole at which it had fired was almost down to the water line, which was touched in about ten minutes. Upon reaching water, the flame was extinguished, but still left gas escaping at the point of entry. As about 120,000 c.ft. of gas was lost, or just one-half the stock held prior to its being hit, it was necessary to get the hole patched at once if the supply was to be kept going. The hole was roughly stopped while a square of ⅛ in. plate was worked to suit the irregular condition of the sheet caused by the entry of the shell fragment. The method of patching adopted was this: Having everything ready, with the gas full on, a cross-bar was inserted inside the holder. The bolt had a length of string attached to it, and was the means for keeping the cross-bar and bolt in position. The patch plate, having a hole to suit the bolts, was passed over the string, and with a red-lead joint the patch was gently pressed home; the string still holding the cross-bar until the nut and washer had started to grip. The other hole in this holder being sealed, attention was next directed to two holes in the crown of No. 1 Holder. These were patched in the same way as above described. Thus by dinner time three holes out of four had been satisfactorily patched, and as all concerned had then been on duty from 9 p.m. the previous night, it was decided to leave the fourth hole, already sealed in the tank, until next day, as by that time all were more or less suffering from the effects of the gas, which it was impossible to avoid inhaling.

In addition to the damage to the holders, the retort-house chimney, some 40 ft. high, which was in a rather weak condition, received its death blow from a shell fragment and also the heavy vibration. This had to be entirely taken down. Other portions of the works hit were the sulphate of ammonia condensers, workshop, governor-house, manager's office, and also the manager's private house. Many portions of shells fell either on or around the works. A section of railway metal, 15 in. in length, was torn up on the opposite side of the river and projected across, just missing one of the holders. The piece of shell which came through the governor-house roof again just missed one of the station-governors. In spite of the experiences, no one was either killed or injured.

BRADFORD.

In pre-war days, several chemical works on the south side of the City of Bradford were engaged in the manufacture of picric acid for the dye industry. During the war, these were given over to the manufacture of various high explosives, and were considerably extended so as to increase their productive capacity. The largest of these was the property of the Low Moor Chemical Company, Ltd., and was for many purposes conveniently situated just near one side of a triangle formed by a junction and a loopline connecting the two lines of the Lancashire & Yorkshire Railway Company, just south-west of Low Moor Station. On another side of this triangle, and close by the railway, were the gas-works erected by the North Bierley Gas Company, and purchased by the Bradford Corporation in 1900. The works consist of a retort-house containing 156 retorts, with exhausters and the usual purifying plant and two holders—a single lift, 100 ft. diameter, of 180,000 c.ft. capacity, and a three-lift, 80 ft. diameter, holding 270,000 c.ft.

At 2.25 p.m. on Monday, Aug. 21, 1916, a terrific explosion occurred at the chemical works, and explosions continued at intervals until nearly 6 p.m., and numbered 22 in all. The most unfortunate result was that 38 persons were killed and many injured—six of the former and twelve of the latter being firemen. The first explosion, though not the most violent, had the most disastrous effect of any on the gas-works. Both holders were well filled at the time. The manager of the works was walking towards the holders when the first explosion occurred; and he was thrown to the ground. On recovering his feet, a very few seconds afterwards, both holders were grounded. The three-lift holder had its crown badly torn open outwards; while the bottom curb of the inner lift was damaged, the side sheets of the middle lift were torn and buckled, and those of the outer lift were badly buckled and torn. The roof trussing was seriously displaced and damaged, and most of the vertical channel stays were buckled. The holder was situated about 275 yards from the scene of the explosion. The single-lift holder crown was torn, but not so badly as in the case of the other one. The side sheets, especially on the side nearest to the chemical works, were torn and buckled very badly, and the roof trussing was seriously damaged. In both holders the guide-framing was not injured; but it was necessary to plumb and adjust it.

The various buildings on the works were all more or less damaged—slates were displaced on every roof, scarcely a window or skylight was left whole—these were all blown outwards, the smith's shop and boiler house (which were situated nearest the chemical-works) were badly shaken, and the boiler flue also. The roof trussing of the coal-sheds and retort-house was damaged seriously—many king bolts and purlins being broken; the purifier house roof was lifted, the walls displaced in several parts, two principal rafters broken, and about 40 ft. of the ventilator with louvre boards blown away; and the offices and two dwelling-houses attached, with the furniture which they contained, were very seriously

damaged. Much of this damage to the buildings was caused by flying fragments, many of them very large, of the chemical-works and plant. Bricks were all over the gas-works, and large pieces of castings weighing up to 1 cwt., wrought-iron piping (one length of 3 in. pipe 26 ft. long was found), and torn portions of steel stanchions of great strength were distributed all over the works; and most of them were red hot when they dropped. Fortunately only two of the Gas Department's men were injured—not seriously.

The district governors, of course, immediately grounded when the holders fell. The outlet valves were closed later in the evening, and the valves on the distribution system (connecting the Low Moor district with Bradford) opened—so that the consumers who remained at home—and they were few—should not be deprived of a gas supply. Early next morning, a number of inspectors were sent round to visit the whole of the unoccupied houses in the area covered by the explosion (these were many) and shut-off the gas at the service taps, so as to avoid any possible leakage through damaged fittings, &c.

Some ridiculous reports of the explosion were current and some found their way into the daily Press. One was to the effect that the gasholder explosion was the cause of the fire at the chemical-works; whereas the fact was that the fire at the chemical-works started ten minutes before the holders collapsed. The gas in the large holder did not fire at all; that in the smaller one was ignited by flying fragments from the chemical-works after it had grounded. The holes in its crown were comparatively small, and the only signs of burnt paint seen were on the lower portion of one column, and close by the torn places on the crown. The large holder crown sheets were torn outwards, and all the windows in the district were blown outwards, as glass could be seen opposite every window strewn right away into the middle of the road. These facts indicate that the damage was not caused directly by the explosions, but by the reaction or rebound afterwards.

The builders of the larger holder were immediately communicated with, and the repair of the two holders put in hand at once; while syphons and pumps were got to work emptying the holder tanks. Owing largely to the delay in obtaining steel, the three-lift holder was not ready for use until the end of November; and on the 27th of November, 1916, gasmaking was resumed. The repairs of the smaller holder were not completed until May 17, 1917.

The writer of this paper happened to attend a meeting of the Yorkshire Commercial Section a day or two after the occurrence just described, when the Chairman, Mr. Charles Wood, gave a cordial invitation to the members present to pay a visit to the Low Moor Gas-Works, and inspect the scene of the disaster. A goodly number availed themselves of the invitation—including the writer, who was much impressed by the palpable signs that the damage to the holder, &c, was not directly caused by the eruptive force of the explosion but by the rarefaction of the air this created, as is pointed out several times in the foregoing description. The violence of this reaction suggested to him the desirability of putting it on record. Hence this paper. The writer's house at Wakefield was shaken, and the windows violently rattled, by these explosions—a distance as the crow flies of about 11½ miles.

TYNEMOUTH.

On the occasion of the air raid over Whitley Bay, seaside resort, on Aug. 8, 1916, when the enemy was supposed to be concentrating upon an attack on the Railway Station, the Gas Company sustained damage to their branch show-rooms. One of the bombs fell in the rear premises of the Whitley show-rooms, which consists of a distribution workshop and general stores, and did very considerable damage. The premises are comparatively modern, having been built at considerable cost by the Company as recently as 1910. To give some idea as to the explosive force of the bomb in question, it may be stated that, though it actually fell in the rear of the premises, the whole of the show-room was practically wrecked, and every room in connection with it practically destroyed—the front windows not even escaping entire demolition. As indicating the thorough manner in which destruction was completed, out of an enormous stock of cooking, heating, and lighting apparatus, there was scarcely a single article which was removed undamaged or unfractured. Fortunately the premises were not occupied at the time by a caretaker; and the building was covered by insurance under the Government aircraft and bombardment scheme. On the same occasion, another bomb fell in the centre of an avenue with houses on either side, and exploded in the road-way, forming a shell hole of considerable dimension and depth, completely shattering one of the 4 in. mains which passed directly through the area in question. Owing, however, to the fact that, in accordance with the usual practice, the pressure had been reduced on receipt of the first warning, to about 4-10ths at the works, there was no fire or other damage caused before the main was restored.

RETFORD.

On the night of Sept. 3-4, 1916, Retford was visited by a Zeppelin. Shortly after midnight the hum of the engines was distinctly heard, and the Zeppelin passed over the town; but as no warning had been given, very little notice was taken of the incident. Shortly after, warning was given, and the hooters were blown. The aircraft, which meanwhile had been hanging over Barnby Moor, some two miles away, and apparently uncertain of its bearings, evidently heard the warning, and immediately returned in the direction of Retford. The first bomb was unloaded about a mile away from the gas-works. Then, having dropped about twelve bombs, the Zeppelin again changed its direction, and, after dropping a flare bomb, made a straight line for the gas-works, unloading in the meantime about fifteen bombs, of which two fell in the gas-works premises, when he evidently found the Great Central Railway, and made his way home. The first of these two bombs fell in a tree between the manager's house and the largest holder, making about 300 holes in this holder, which was full (capacity 210,000 c.ft.), and causing considerable damage to the manager's house and orchard.

The second bomb dropped at the edge of No. 2 Holder, which was at the time quite full (capacity 135,000 c.ft.), making a large hole in the side sheeting; the sheeting being blown up into, and twisting round the roof trussing of, the holder. Splinters from this bomb also went right through the holder, causing considerable damage to a small holder (No. 3). The gas immediately ignited in all three holders; and the light of the burning gas was seen as far as forty miles away. The valve-room situated close to No. 2 Holder caught fire; but it was fortunately got under after playing on it with water for a considerable time, and the holders burnt themselves out. The doors of the fitting shop and pipe-stores were blown in by the force of the explosion, but the buildings did not catch fire. The next morning the works presented a very pitiable sight. The small holder was patched as quickly as possible, and the supply of gas was re-commenced in nine days. It is evident the Zeppelin man was uncertain of his situation, as the German report stated that Sheffield, which is 23 miles away, had been bombed.

SOUTH METROPOLITAN GAS COMPANY.—SILVERTOWN EXPLOSION.

This explosion occurred at about 6.52 p.m. on Friday, Jan. 19, 1917, and the shock experienced at the East Greenwich Gas-Works was very severe, causing the No. 2 Gasholder to be completely wrecked, and the No. 1 to be very seriously damaged; while large numbers of slates were torn from the roofs, windows broken in all directions, and the works generally severely shaken. Before saying more about the No. 2 Gasholder, which was the most serious damage sustained, and the extent of which only became known upon close examination after the occurrence, it might be interesting to narrate the effect the explosion had upon the works generally and upon those present at the time. At the offices of the works, which are close to the river side, and some 700 yards away from the gasholder—the report was terrific—the floor appeared to heave, the building rocked. This was followed by a blinding glare seen through the venetian blinds, and lasting a very few seconds, during which it seemed to be as light as day outside. Then the glare ceased, and the north eastern sky was suffused with the glow of a tremendous fire. The source of the shock and the report was at once apparent. Those in charge immediately rushed to see whether any damage had been done to the carbonizing plant—more especially on the vacuum side of the exhausters. The boiler attendants and engine drivers, however, said that all was well with their plant; but somebody said "No. 2 Gasholder has 'gone up.'" It was evident, however, that a supply of gas was being maintained; for though some lights had been blown out, many were still burning.

The damage sustained by buildings was found to be practically confined to windows and doors. The windows of the offices, engine-rooms, and shops were extensively smashed,

window frames were dislodged, and one or two heavy doors blown off their hinges. The floor of the engineer's office was thickly strewn with small pieces of plate glass from end to end of a long narrow room, and a 4½ in. partition between it and the stores had been severely shaken. The roofs of buildings, apart from the stripping of slates, which was not extensive, escaped uninjured, also the retort-house shafts. No. 7 coal-store, however, the nearest to the coal-store, sustained some damage. Here the roof principals are carried on columns placed about 30 ft. apart on the coal-store wall, and the spaces between them are filled in with corrugated sheeting, having a timber stiffener, 6 in. by 4 in. by 16 in., in the middle of each bay. Eleven of these, out of a total of fourteen, were broken.

With regard to No. 2 Gasholder, this was built in 1891, and had a working capacity of approximately 12 million c.ft. when fully extended. The holder comprised six lifts, of which the first and second were "flying lifts," the outer lift being 300 ft. in diameter. The depth of the lift to the rest stones is 31 ft., and the rise of the crown 25 ft. The stock of gas in this holder at 6 o'clock being only 7,865,000 c.ft. proves that the top lift was well within the guide-columns at the moment of the catastrophe. In other words, so far as the working conditions are concerned, the holder, at the moment of the shock, was probably in the very best position to resist any unusual or special strain, such as a gale of wind or drifting snow, provision for which had been foreseen and was duly provided against. The holder, however, had not been built to stand-up against the shock of an explosion of a large quantity of T.N.T. occurring at a distance of 1½ miles as the crow flies.

It would appear to be clear that the holder was wrecked either by the pressure produced in the atmosphere by the explosion or to the vacuum immediately succeeding it. That a tremendous shock resulted from the explosion is shown by the fact that windows and doors were blown outwards or inwards many miles from the scene of the explosion; and at the Old Kent Road works, which is some four miles distant as the crow flies, a holder of 5½ million c.ft. capacity was seen to rise and fall from 1 ft. to 3 ft. according to the testimony of eye witnesses. The extent of this disturbance is borne out by the chart registering the district pressure, which oscillated between 46-10ths and 55-10ths, settling down to its normal pressure of 50-10ths in the space of from five to eight minutes, so far as can be ascertained by the state of the chart.

It may be mentioned that the blinding glare which was observed throughout the whole of London at 6.52 p.m. on that January evening, the lightness of which has been compared to that of a summer day, was undoubtedly due to the burning in a few seconds of 8 million c.ft. of gas contained in this holder.

South Metropolitan Gas Company.—Damage by Hostile Aircraft.

West Greenwich Works.—The first damage to the Company's property occurred on the night of Aug. 24, 1916, when two incendiary bombs were dropped on the West Greenwich Gas-Works. The first fell through the roof of a lobby used by the yardmen, into an iron-store below. In its passage this bomb damaged the roof, a table and bench in the lobby, and passed through the floor, damaging the doors of the iron-store below, and was finally extinguished with a hose pipe. The second bomb fell on a small gasholder (No. 4), passing through the crown into the tank below, and causing a loss of about 10,000 c.ft. of gas; but the gas was not ignited.

Vauxhall Works.—On Jan. 28, 1918, damage was done to the Company's property. Several incendiary bombs were dropped in the neighbourhood. One fell on No. 1 Retort-House. Passing through the roof, it broke away an overhead platform and, falling into the retort-house, exploded, perforating the pressure pipes on two hydraulic machines, damaging a retort-bench, an iron staircase, tearing-up stage plates and floor girders, and blowing all the windows and sashes out of the engineer's office, timekeeper's office, and works office. The extent of the damage on this occasion may be realized by the fact that it cost nearly £2000 to effect the necessary repairs.

East Greenwich Works.—On Jan. 28, 1918, two incendiary bombs were dropped on the Company's land, which was being used as allotments, just inside the boundary wall of Blackwall Lane, and about 600 yards away from the gas-works. The bombs were dropped separately, and about 200 yards apart; no damage being done.

Old Kent Road Works.—No bombs were dropped on this works; but during September, 1917, a shell and nose cap from one of our anti-aircraft guns fell through the roof of the purifying shed, breaking many slates and burying itself in the floor of the shed. Also on May 19, 1918, as the result of an air raid in the vicinity, a piece of granite, weighing 25 lbs., was thrown through the roof of the purifying-shed, breaking a number of slates and causing a considerable dent in the purifier lid upon which it fell.

The other works of the Company, including show-rooms and gasholder stations, fortunately escaped damage, though on several occasions narrowly; bombs being dropped very close. A good deal of shrapnel was picked up at the various works; but this did little damage.

Southend.

Southend, like most towns on the south-east coast, has had a large share of raids from enemy aircraft. On several occasions the raiders were well over the coast before any warning was given; and it was no uncommon thing when this occurred for operations in the retort-house to be interrupted with Gothas and shells flying overhead. Anxious moments were then spent in closing-down, and in many cases gas making was not resumed for a period of nine hours. So far as the works were concerned, no damage was sustained, although many large pieces of shells from the neighbouring anti-aircraft defences found a convenient resting place on the property of the Company. However, it was hardly possible that the district should prove to be so immune from damage as the works; and in the first raids experienced, which were from Zeppelins, much damage was caused by incendiary bombs, chiefly in residential property. Damage was sustained in these cases by the gas-meters.

No mains were hit until the daylight raid on Aug. 12, 1917, when the leading trunk main and a 10 in. high-pressure main running parallel with it were severely damaged. These mains were hit by an aerial torpedo, which (judging from others that fell in the town but did not explode) weighed approximately 132 lbs., and was 5 ft. 9 in. in length. It evidently struck the high-pressure main, cutting it completely in two. The heat generated by the explosion was so intense as to destroy the nature of the metal for several yards. It is interesting to note the fusion of the metal on the steel-main.

They say "It is an ill wind, &c.;" and, fortunately for the Gas Company, a neighbouring water-main was also fractured, releasing a sufficient volume of water to practically seal the high-pressure main before any ignition of gas took place. The leading cast-iron trunk main suffered severely from the concussion; but fortunately it did not collapse. However, considerable care had to be exercised to nurse the fractured portion with clay, and other temporary expedients, until more permanent repairs could be executed.

Ashton-under-Lyne.

During the afternoon of June 13, 1917, a fire broke out at a "T.N.T." works in Ashton-under-Lyne, followed later by a violent explosion. This took place about 4.20 p.m.; and caused the death of 49 persons and injury to about 700 others. Scores of houses were wrecked, besides great damage to other property, including the two largest gasholders; the capacity of each being 854,000 c.ft. The holder yard was separated from the T.N.T. works by the width of the street, and from the actual scene of the explosion to the gasholders would be about 50 yards.

At the time of the explosion the last two sheets of No. 4 holder were being painted. The holder was fully inflated, and was 60 ft. high. No. 3 holder was half full; the outer lift being in the tank. When the explosion took place, the débris from the T.N.T. works was blown in all directions—bricks, boiler plating from the stills, and girders were found in the tanks when empty, besides what pierced the holders from side to side. Some of the fragments of metal weighed over 100 lbs. The holders, being well-up, took the full shock of the explosion, and undoubtedly saved the property behind them. The holders were lifted to the opposite side of the holder tank from the T.N.T. works. The gas in the holders (about 1½ million c.ft.) caught fire; and, when nearly burnt out, the valves of the holders were at once closed—they being then a mass of ruined materials. After the holders were shut-off from the town and works, which are roughly a mile away, steps were taken to get everything

safe as quickly as possible. Uniformed men were therefore sent down to the scene of the explosion; so that, in the event of gas escapes, they would be easily recognized and called on for help. They had plenty to do.

No time was lost in regrets. An immediate start was made to empty the tanks of water ready for the contractors, whoever they were to be. But it was no easy task to get about 11,000 tons of water out of a tank 32 ft. deep. It was necessary to do this before the full amount of the damage could be estimated. No. 3 holder was the best of the two to tackle in restoration, because the outer lift could be used again after repairs. Through being in the tank at the time of the explosion, the chief damage caused to it was from the columns and girders, &c., which had been blown into the tank, penetrating the plates in places. The inner lift of No. 3 and the whole of No. 4 holder were hopelessly damaged, and had to be entirely renewed. The contractor's first task was the dismantling of the columns and girders in danger of collapsing; afterwards the removal of the material lying in the tanks.

When the water had been removed from the tanks, and an examination made of the damage done, it was decided, after a consultation with the contractors, not to wait for a similar holder to be erected, owing to the difficulties likely to be experienced in getting material, but to convert them to the Gadd and Mason principle, and do away with the columns and girders. Even under these conditions it was unfortunate not to get the material as fast as was wanted, and with bad weather and little troubles the contractors had with their men, the first holder was not completed until the middle of January, 1918. The second holder was completed in the following October. There was nothing but praise for the contractors, who carried out their work in a first-class manner without accidents, and under most difficult and dangerous conditions.

Being summer time when the accident happened, there was no serious handicap for maintaining a full gas supply until some weeks later, because there were two holders at the works intact, with a capacitty of 200,000 c.ft. each. About three weeks after the explosion, one of these holders would not cup properly; so that the inner lift only of this one could be used. Grabs were made to go round the tank to pick up what was possible from the bottom, so as to allow the outer lift to ground properly. It was September before success was obtained. The trouble was caused apparently through children throwing things into the tank, which was quite easy for them to do; the holders being close to the street where children play.

During the winter months, there was only storage for three hours of the maximum demand. Therefore far more furnaces and beds had to be kept under fire than would have been necessary otherwise. The greatest troubles were after 12 midnight and at week-ends. The men had to stand for half the shift because the holders were full. During the day-time—say, after 7 a.m. until 10 p.m.—it was a case of charging and drawing for all the men were capable of, because of the heavy demand of mills and munitions shops. If the holders uncupped, they only gave 25-10ths pressure, which was lower than was liked. But it had to put up with nightly in winter from about 6 p.m. to 9 p.m., when the holders would get cupped again. The gas supply never failed, and only once was the pressure reduced below 2 in. in the day time, and then only for about four hours one very misty day to 18-10ths, and the mills, &c., were all lit up. Perhaps it would be better not to recite everything that had to be done to keep going, but success attended the efforts of the management right through.

There were some other little troubles beyond the holder difficulties. A pick got into the breaker of the "D.B." plant and smashed one side of the breaker. This was on Jan. 3, 1918. Coal had then to be selected, and the lumps broken and put into the buckets of the elevator with a shovel—not less than 100 tons per day—until Feb. 18. The back axle of the "D.B." stoker sheared right in two on a Saturday in March; and it took until Sunday night to put it in order again, working right through. Fortunately, a spare axle was available. During the temporary breakdown, pipe fitters, bricksetters, lamplighters, and others were brought into service to keep going. Next the "Standard" washer acted similarly, shearing a 5 in. shaft in two. This took weeks to get right, owing to the difficulty of getting material; but it was done locally.

Looking backwards, there is no desire to go through the same ordeal again, as the war being on made everything more difficult to overcome. But the management were very grateful to all the men, as they never hesitated to do anything that was asked of them. Stokers would go and help in the purifier-house after their shift if needed, and yard men in the retort-house. It was only through everyone doing the best possible that the works came through so triumphantly. All the staff helped magnificently throughout.

DUKINFIELD.

The gas-works were the nearest large object in Dukinfield to the scene of the explosion at the T.N.T. works in Ashton-under-Lyne on June 13, 1917, and both the holders in operation at these works were immediately wrecked, and the escaping gas fired by the hot metal, &c., scattered by the explosion. The resulting flames enveloped several men, who were badly burnt; and one of them unfortunately succumbed to his injuries. The roofs of the retort-house, coal-breaker house, smithy, and governor-house were severely damaged by the flying pieces of girders and machinery, as also were the walls of the governor-house and the gas-engine room. Nearly every window in the works was blown out; and in many cases doors were wrenched from their hinges. The oxide-sheds were particularly badly damaged. The supply of gas was cut off for several days.

RAMSGATE.

In all, Ramsgate was threatened by enemy aircraft on 119 occasions, although on only ten were bombs dropped in the town. In the majority of cases enemy aircraft were driven away through anti-aircraft action. The total number of bombs dropped was 123; and on two occasions, during bombardments by destroyers, well over 300 shells were thrown into or over the town. In all, some fifty houses were wrecked; the services, gas-fittings, meters, stoves, &c., sharing the same fate. Several hundred houses, among other damage, had their gas-fittings, pipes, &c., ruined; and in twelve places gas-mains were broken.

The most serious damage so far as the Gas Department was concerned occurred on Oct. 31, 1917, when, at 12 o'clock midnight, two bombs were dropped on the works, and one in the main road immediately above the works. One bomb fell at the right-hand corner of the purifiers, and must only have missed them by about 2 ft. The roof over the purifiers was shaken, and several plates in the purifier-boxes and uprights were cracked and perforated by pieces of the bomb. At the time the bombs fell, the two-lift holder on the right-hand side was about three-quarters full of gas, and the sheeting was perforated in 110 different places through flying fragments of the bomb; the perforations running from 1 in. by ½ in. to 8 in. by 1½ in. inside. All the perforations were in the upper lift. The three-lift holder, on the left-hand side, had ten small perforations, averaging about 1 in. by ½ in. inside. The bomb which dropped on the roadway immediately above the works broke three trunk mains. Hence the predicament the works were placed in through the smaller holder being out of action and the larger holder being emptied through the broken mains as quickly as gas could be made. For two days there was less than half-an-hour's supply of gas available in stock. The whole of the roof covering the purifying shed was raised 2 in., but fell back into position again. The second bomb fell at the back of the offices.

BRENTFORD.

Warning of an impending raid was received at 9.55 p.m. on Wednesday, Jan. 29-30, 1918; and the "All Clear" given at 1.10 a.m. The enemy approached by the north-west of the gas-works, passing just to the north, and proceeded in an easterly direction. Bombs were dropped at 11.20 p.m. in rapid succession. The first fell in Whitestile Road, two-thirds of a mile north-west of the gas-works, by which three houses were demolished and seven persons killed, followed by one at Enfield Road, which caused slight damage to property only—one on the railway goods line, opposite "Clayponds," one (unexploded) in the south embankment of the railway, two close together in a field near St. George's Schools, one in the water-works reservoir at the back of No. 4 gasholder, one at the back of the Gas Company's stores building, one on the water-works office (the office was demolished, and other damage caused to the gates and front of the works, and two men killed), and one on the meter-works fitting shop. Bombs also fell on the London and South Western Railway Station, Kew Bridge (one), junction of Kew Bridge Road and Stile Hall Gardens (one), junc-

tion of Main Road and Wellesley Road (one), and one in the allotment grounds north of Ellesmere Road, Chiswick.

The roof of No. 1 retort-house was broken by a piece of railway metal about 20 in. long, and weighing 15 lbs., which was found on the bridge-pipes on top of the retort-beds. This was proved to have been caused by the third bomb, which fell on the railway a quarter-of-a-mile away. The 6 in. gas-main was broken, together with a 36 in. water-main at Kew Bridge Station (London and South-Western Railway); and water subsequently washed away the soil from under the 36 in. gas-main on the north side of the road. At the corner of Stile Hall Gardens, the 26 in. gas-main was broken by the bomb (which fell exactly in the centre line of main, just to the western side of the valve) setting light to the gas and causing a flame about 40 ft. in height.

The effect of this large fracture was immediately felt at the gas-works; the initial pressure dropping from 41-10ths to 9-10ths for the moment. This quickly rose to 25-10ths (oscillating). Within a quarter of an hour, the valves on the western side of Kew Railway Bridge had been closed, whereby the gas-flame issuing from the hole in the 26 in. main was reduced in height from about 40 ft. to 20 ft. It was impossible to get near enough to the flame to enable the valves on the eastern side of the bridge to be closed; so the pressures were reduced at the Brentford and Southall works until about 10-10ths of an inch was maintained at the Chiswick show-rooms (1½ miles distant)—viz., 25-10ths at Brentford and 20-10ths at Southall; Brentford feeding Hammersmith and Chiswick through the 20 in. main, *viâ* Strand-on-Green and Burlington Lane. At 4 a.m. 20-10ths was registered at Chiswick, Brentford 25-10ths, and Southall works 40-10ths.

Sand was then procured from the Chiswick Urban District Council yard and thrown into the hole (loose and in sacks) until the flame was reduced in height to about 5 ft. It was then found that the valve on the 26 in. main close to the place where the bomb fell could not be shut. At about 2 a.m., an excavation was begun on the 26 in. main; and on the 6 in. Stile Hall Gardens main—the latter being cut and capped both ways, and the former bagged off at 9 a.m.—thus extinguishing the flame. The ground was then opened around the 26 in. main at the spot where the bomb dropped. The valve was found to be cracked in the flange on the western side; so a wooden plug was inserted and clayed-up, and a timber strut driven between the plug and the end of the gap. [The 26 in. main west of the valve was left capped-up, jointed temporarily with yarn, after removing the fractured portion.] The bomb had broken the top of the main, which had about 2 ft. cover, and had expended itself inside the main; the bottom of the pipe being unbroken. A new 26 in. valve was at once ordered, and the ground filled-in pending delivery. Until 11 a.m. the pressure at Chiswick was 8-10ths to 15-10ths; the maximum pressure at the Brentford works being 45-10ths and at the Southall works 76-10ths. At 3 p.m. on the same day, the auxiliary main (36 in.) in the south footpath of Kew Railway Bridge was opened, and normal pressures worked through to Hammersmith. The damaged two-flange valve was removed on the 18th to 19th of February; and the new valve was fixed on Feb. 22, 1918. The loss of gas is estimated to have been about 380,000 c.ft.

The foregoing particulars prove conclusively how safe gas-works really are. Numerous gasholders have been destroyed by enemy shells, by bombs from hostile aircraft, and by explosions at adjacent munition works; but in every case the gas contained in them has either escaped harmlessly into the air or has quietly burnt itself out. In the case of the Silvertown disaster, no less than 8 million c.ft. were fired, and London lit-up by the blaze; but there was no explosion or damage done except to the gasholder itself. This should surely remove the long-existing prejudice of the public, and show them how groundless their apprehensions are.

Another lesson to be learned from the foregoing narrative was the utter futility of the idea, so prevalent among the military authorities and chief constables of the country, that gas could be shut-off altogether at the gas-works; for it is on record that people were still burning the gas stored in the mains in the high parts of Hartlepool sixty hours after all the gasholders had been destroyed by enemy shells, and the gas burnt which they contained. Ample evidence is afforded of the correctness of the gas managers' view, so universally held, that the safest plan was to keep the mains charged with gas at the lowest pressure necessary for the purpose; and the fact that in not a single instance where gas-mains so charged were destroyed by shells or bombs did any explosion occur, or damage be done to surrounding property, should reassure the public mind, and prove that the distributing mains in the district are as safe as the gasholders at the works.

It now only remains for the writer to heartily thank those gentlemen who have so freely placed the record of their thrilling experiences at his disposal. Pressure of time and space has compelled him to omit much interesting detail from the accounts sent him; and the wealth of information supplied has forced him to assemble, in the following appendix, many highly interesting contributions for which it was not possible to procure photographs.

APPENDIX.

SCARBOROUGH.

No great damage done to the gas-works by the bombardment on Dec. 16, 1914, can be reported. The total damage consisted of a piece of shell going through the crown of the water-gas relief holder, which was promptly repaired. The expense, including the loss of gas, did not exceed £1. On Sept. 4, 1917, the town was also bombarded by a submarine; and a shell which exploded in Cambridge Street broke a piece out of an 8-in. main, which was, however, speedily repaired.

WHITBY.

Fortunately no damage was done to the gas-works by the bombardment of the German cruisers on Dec. 16, 1914, although two pieces of shrapnel fell on the holders. A 3-in. main was broken by the explosion of a shell; but this was promptly repaired.

GORLESTON (GREAT YARMOUTH) AIR-RAID.

On the evening of Jan, 19, 1915, at about 8 o'clock, loud explosions were heard. These became nearer and nearer to the gas-works. It was soon evident that the country was in the grip of the first Zeppelin air attack, and that the first taste was being experienced of what Germany called "war." A deafening explosion took place in mid-air over the centre of the river, on the banks of which the works stand. The fragments scattered in all directions. At the time two steamers were lying alongside the works opposite to the two gasholders. A good number of fragments pierced the steamers' funnels; and their force having been broken, the nearest holder received a peppering. But apart from depressing the side sheets, no punctures were made. The hardest hits were received on the guide columns. The holders appeared to have the effect of breaking the concussion, as houses some distance from the holders had their windows broken; while the other path was towards the workshop and the station-meter house. The whole of the ⅛-in. plate glass in the workshop sashes was smashed; and glass in other parts of the works, both inside and outside, suffered. Very fortunately no one was injured on the works. On the occasion in question the whole town was lighted, as were also the works; so that the observer had every opportunity to get near to his points of attack.

BRIDLINGTON.

On April 18, 1915, at 3 a.m., orders were received from the police to shut-off the town's gas supply. As nearly every house had lights burning, the instructions were not obeyed. Later in the day the Company wrote the Police Superintendent asking for an assurance that they should be relieved from responsibility for danger to life and property if such order were obeyed. The Chief Constable of the East Riding replied that Police Orders under D.O.R.A. to shut-off the gas must be carried out, and consumers must be warned that gas might be cut-off at any time during the night. Legal opinion was that, even if no notice were given to consumers, there would be no liability on the Company for the consequences of obeying orders issued by the police under D.O.R.A. Nevertheless a warning circular was sent out. Thereafter consumers generally ceased to leave jets or heaters burning all night; and when ordered to do so by the police, gas was shut-off at the holder outlet valves. No accidents from this cause had been reported, although the supply was turned on again as soon as the "All Clear" signal was received on each occasion. All street lamps are electric.

Upon the holder valves being closed, the gas went out practically all over the district—usually in a few seconds.

In one or two houses, both at high and low levels, a light could be obtained for some hours, while everywhere else no light could be got—pressure in house pipes falling to atmospheric. At the station governor it fell to zero. Immediately gas was turned on again, it burned as usual, with no sign of air dilution. The Company were ordered to cease work in the retort-house when air-raid warnings were given. This involved trouble when the stoppage exceeded, say, three or four hours. The exhausters were driven by gas-engines connected to the holder outlet mains. The second order to shut-off came without warning, before there had been time to connect-up to the holder inlet. The engine stopped; and a good deal of gas was thereupon lost. A supplementary pipe from the holder inlet main was laid for occasions when the outlet valves were shut. After this the exhausters were able to be run as long as there was a sufficient make. It seems curious that the Company should have been compelled to put the town into absolute darkness, while other towns in the district were not compelled to do so.

BURY ST. EDMUNDS.

The first air-raid was on the night of April 29, 1915. The night was clear, with a nearly full moon. A single Zeppelin came along absolutely without any warning. It made a circuit of the town, dropping about thirty bombs *en route*. Then it vanished as quickly and mysteriously as it arrived. Most of the bombs were incendiary, and caused two rather serious outbreaks of fire. The gas supply was shut-off at the works, and not restored until 8 o'clock the following morning. The only loss sustained was the destruction of two or three consumers' meters. This was the only occasion on which the gas supply was shut-off. There were many alarms subsequently; and on four or five occasions Zeppelins actually passed over, and hovered over, the town, but without dropping anything. The second and last raid that occurred was on the night of March 31, 1916. Ten or twelve high explosive bombs were dropped, eight people were killed, and much damage was caused to property. No damage whatever was done to the gas plant, mains, or meters. The Company never made a practice of reducing pressure or shutting-off the supply after the first visitation; the view being held that it would cause a lot of unnecessary alarm and confusion. The street lighting is all electric, and was discontinued entirely after the first visitation.

HULL.

The gas-works were first warned of the possibility of air raids by Zeppelins in January, 1915, when alarm buzzers were erected in various parts of the town, and arrangements made for action on the part of special constables, St. John Ambulance workers, and other volunteers. At the gas-works were a number of volunteers, who paraded whenever an alarm was given. These men were provided with pick and shovel, fireman's axe, and electric torch lamp. On each alarm, all the fire-hose on the works were coupled-up ready for action; and, in addition, a considerable stock of good, soft, wet clay was kept ready for any emergency. At the district workshops, in the centre of the town, another group of volunteers paraded. They were furnished with similar tools; and a stock of good, soft, wet clay was always ready, together with the usual main-laying carts and tools. The works were placed upon the Military list, and received preliminary warnings before the general alarm was given. This necessitated the attendance of two men at the Central Office in the district continuously from January, 1915, to the time of the signing of the armistice on Nov. 11, 1918. One of these men was a despatch rider for the purpose of summoning the other workmen. At the works, the assistant was in constant attendance on the telephone from sunset to sunrise each day. One of the chief precautions was to ensure that the town was in complete darkness at the earliest possible moment after the sounding of the alarm. For this purpose, the services of all the district men were enlisted to supplement the ordinary lamplighters in extinguishing the lamps when an alarm was given. The method was as follows: When the preliminary warning was received, the despatch rider immediately called up eight other despatch riders, who summoned the whole of the 80 to 90 men, and warned them to be ready. Each one of these men went to his appointed station; and, as soon as the general alarm sounded, he proceeded with all speed to extinguish his quota of lamps. By this means the city was completely darkened in less than twenty minutes from the sounding of the general alarm.

The first raid occurred on a calm, clear, starlight Sunday night (June 6, 1915). There had been some alarms prior to this—namely, April 12, 1915, May 11 and 12, and June 4; but nothing had happened on these occasions, and people began to wonder whether there was any real danger or not. However, about midnight on June 6 there was the unmistakable noise of a Zeppelin overhead, followed by some terrific explosions. There were several fires, some of them of considerable extent. The total number of casualties for this raid was 64—including 19 killed outright, and 5 who died from shock. Most of the damage was to poorer class property; but a large shop was burnt down, doing damage to the extent of about £100,000.

The next raid was on March 5, 1916—another Sunday evening; and the ground was covered with snow. About midnight the noise of a Zeppelin was heard overhead, quickly followed by a number of explosions. There was a good deal of damage to poorer class property. The number of killed was 18, and of injured 52. After this raid, guns and searchlights were installed. The Zeppelin revisited the town on April 5, 1916, but was driven off rapidly. Only one bomb was dropped; and that was without injury to life, although there was one death that night from shock.

About 1.15 a.m. on Aug. 9, 1916, there was another raid; but for some unknown reason the defences were not in action. Several bombs were dropped, and unfortunately 8 people were killed and 22 were injured. On Sept. 2, 1916, a Zeppelin arrived about 12.40 a.m.; but it received a very hot reception from the guns and searchlights, and beat a hasty retreat without dropping any bombs. There was another visit on Sept. 24, 1917. Several bombs were dropped; but no one was injured. Again on March 12, 1918, at about 1.15 a.m., a Zeppelin arrived. It was met with a lively barrage of searchlights and guns, and beaten off after dropping its load of bombs in the outskirsts of the city. The last raid was on Aug. 5, 1918, at 1 a.m. The searchlights were in action at once, and the Zeppelin quickly disappeared. No bombs were dropped, and no casualties of any kind occurred.

The total casualties for the whole of the raids were: Killed, 43; died from shock, 11; injured, 115. The alarm buzzers were sounded on 53 occasions; and the total number of hours of waiting until the release was given amounted to 206. Although the damage done in the city was very considerable, the gas-works were extremely fortunate. The only damage sustained there was a number of broken slates and skylights, due to anti-aircraft shrapnel. Upwards of 100 shrapnel bullets and several pieces of shell were collected from the roofs after one of the raids.

In one street in the city, despite the fact that there was a shell crater which reached to the bottom of the main sewer, and in many other places gaping craters, there were only two small gas-mains cracked; and these were easily attended to. A curious circumstance was that there were recovered nearly 100 prepayment meters from the *débris* of the ruined cottages; and not one was injured. This was due to the fact that each meter was placed in a small cupboard under the stairs; and this proved to be sufficient protection for the meter.

COMMERCIAL GAS COMPANY, LONDON.

The damage to the Company's property during the period of air-raids was comparatively slight. The works escaped damage entirely, except for a few broken slates, &c., caused through fragments of shell. The damage to the Company's mains and service pipes on the occasion of the various raids was as follows: Two 6-in. mains broken, one 5-in. main broken, four 4-in. mains broken, and one 3-in. cast-iron service pipe and about a dozen wrought-iron services damaged. A few meters and fittings were broken in some of the houses which were damaged.

SOUTH METROPOLITAN GAS COMPANY—DAMAGE TO DISTRIBUTION PLANT.

Of the tweny-five air-raids which London experienced during the war, fifteen caused damage to the Company's plant, distributed over the district served by them. It was on Tuesday, Sept. 7, 1915 (the second raid on London), that bombs were dropped for the first time within the area supplied by the Company. Three mains—a 4-in. in Deptford, a 5-in. in Bermondsey, and a 6-in. in Woolwich were broken; and the joints of two others in Deptford and New Cross had to be set-up. Damage was also done to several slot meters, fittings, &c. In Woolwich, owing to the damage to

a water-main, and consequent flooding of a gas-main, it was necessary to keep the syphon pumps going all night.

The second visit was on Friday, Aug. 25, 1916 (the fifth raid on London), when a 9-in. main in Dickson Road, Well Hall, was broken. Meters, stoves, and fittings were also destroyed in Blackheath. Soon after midnight of Sept. 23, 1916, was the third experience; the damage this time being almost entirely confined to the main thoroughfare, and turnings therefrom, reaching from Streatham Common to Kennington Park. Fortunately, no damage was done to the mains; but several meters, stoves, fires, &c., besides a street lantern, suffered.

Wednesday, June 13, 1917 (the ninth on London, and the fourth in the Company's area), witnessed the first daylight raid over the Company's district. A 3-in. main was broken in Linden Grove, Nunhead, and two large meters damaged in Southwark Street.

Raid No. 10, the fifth in the Company's district, on Saturday, July 7, 1917, marked the famous daylight raid when twenty German Gothas took part. The Company's share of the general damage was repairs to 4-in. main in Harris Street and Charlton Road and a 5-in. main in Spa Road.

Raid No. 13, the sixth in the Company's district, was on Tuesday, Sept. 25, 1917. This resulted in a broken 4-in. main in Marcia Road, Old Kent Road; and meters, stoves, and fires had to be brought away from private houses.

Raid No. 15, the seventh in the Company's district, was on Sunday, Sept. 30, 1917, and necessitated repairs to a 3-in. main in Trinity Street, Woolwich, and a stove was also destroyed in Marshalls Grove.

Raid No. 17, the eighth in the Company's district, occurred on Friday, Oct. 19, 1917—that awe-inspiring silent raid, which proved the last of the Zeppelin visits to London. Bombs or aerial torpedoes caused havoc to many meters, stoves, slot fittings, pipes, &c., in Camberwell and Hither Green. In the latter place, a 4 in. main was broken.

Raid No. 18, the ninth in the Company's district, was on Oct. 31, 1917. On this occasion the Company only sustained damage to the extent of a service in Alpha Road, Rotherhithe.

Raid No. 19, the Company's tenth, was on Thursday, Dec. 6, 1917. Two 6 in. mains were broken—one in Blackheath Park, and the other in Hither Green Lane; while a street lamp by Dulwich Park, and a service on Dulwich Common were damaged. Also slot fittings, meters, &c., in Paradise Road, Burgoyne Road, and Wickham Gardens were destroyed.

Raid No. 20, the eleventh in the Company's district, occurred on Dec. 18, 1917, and resulted in damage to five meters in Spa Road, Cherry Garden Street, and Vauban Street, and broke a 1¼ in. service pipe in Southwark Park Road.

Raid No. 21, the twelfth in the Company's district, was on Monday, Jan. 28, 1918. A street lamp column, a 1½ in. service, and the joints of the main in Wandsworth Road sustained damage.

Raid No. 23, the thirteenth in the Company's district, was on Saturday, Feb. 17, 1918. The 6 in. main in Hither Green Lane was again damaged; and three street lanterns had also to be repaired. A new column and lanterns had to be supplied in Searles Road, Old Kent Road, and Grand Depôt Road, Woolwich; while many meters, stoves, and fittings were damaged or destroyed.

Raid No. 24, the fourteenth in the Company's district, on March 8, 1918, resulted in damage to a 4 in. main, services, lamp-column, and lantern in Battersea.

Raid No. 25, the fifteenth and last in the Company's district, was on Whit-Sunday, May 19, 1918. This proved a record raid so far as damage to the Company's mains was concerned—leaving them with a 7 in. main to repair in Rotherhithe New Road, a 7 in. main in Verney Road, Rotherhithe, a 4 in. main in Undercliffe Road, Lewisham, a 4 in. main in Longhurst Road, Lewisham, and 4 in. and 9 in. mains in Sangley Road, Catford. Also many meters, stoves, slot fittings, &c., were damaged or destroyed in Rotherhithe, Peckham, and Catford. Altogether 21 mains were broken; many services had to be relaid; and 17 meters, 25 stoves, and 2 fires, together with 68 sets of slot fittings, pipes, &c., 5 lamp columns, and 10 lanterns were destroyed, in addition to which a large number of meters, stoves, &c., had to be brought away owing to the premises in which they were in use being rendered uninhabitable. An appreciable amount of work also had to be done in setting-up the joints of mains in the various affected areas.

SUNDERLAND.

On the night of Saturday, April 1, 1916, the Field Marshal's warning was received about 8.15, followed at 9 o'clock by "Take Air-Raid Action," when the pressure of gas was reduced by the Company, and the electric supply cut off by the Corporation Electricity Department. At 11 o'clock the first bomb dropped about five miles distant; and shortly after a Zeppelin could be heard approaching from a south-westerly direction. The first bomb dropped in the Company's area of supply did not explode. The second one, however, dropped in Pickard Street, where very considerable damage was done to dwelling houses and the property of the Company, and others were dropped in quick succession in various parts of the Company's area. In North Bridge Street (in the centre of the Company's area), a bomb fell on the main thoroughfare, close to a stationary tramcar, tearing-up the tram rails, wood blocks, and concrete foundations to a depth of 3 ft.; and several feet length of an 8 in. gas-main and 12 in. water-main running parallel were blown away. Before the water could be turned off, the gas-main, all the syphons, service-pipes, meters, and fittings in the low-lying districts along by the river (where quite a number of large works and houses are situated) were flooded, with the result that when the consumers turned on the taps, jets of water squirted-up to a height of several feet. As soon as this was observed, the plugs in the syphons were taken out, and streams of water about 7 ft. high were at once emitted. After they had been allowed to clear themselves as far as possible, gangs of men were put on in relays until the water was cleared. It was possible to complete this work in the course of the next day (Sunday), and everything was ready for the resumption of the supply by six o'clock on the Monday morning. The 8 in. main was repaired next day in the usual way; the only difficulty being the clearing-out of the sand and other material taken in by the water.

There were also a 3 in. main and two 6 in. mains broken, As soon as the damage done was ascertained, the pressure of gas was further reduced at the works—thus giving a better opportunity to the workmen of getting to the broken mains, which were bagged-up at either side of the damage, and plugged till daylight, when they were repaired.

Apart from the serious damage done to life and property, in addition to the mains referred to, there were thirty slot installations completely destroyed, and forty slot meters, fifteen cookers, and eighteen ordinary meters damaged. One 100-light meter in the low-lying district burst, owing to the pressure of water.

YORK.

The main that was damaged in the first raid here was an 18 in. one. It was 2 ft. 3 in. below the surface, and was laid under the middle of the foot walk, which was flagged. It appears that the bomb dropped directly on to the main. The pressure at the time was 5-10ths. When the spot was reached, the extent of the damage could not be ascertained, because the hole made by the explosion was filled with bricks from a lodging house front which was blown in. The break was isolated by shutting-off the gas at the works and closing a valve in the city. But there was a lot of gas about; and several men were gassed when doing the job. It was found that about 3 ft. of the main had completely disappeared; and not the smallest fragment was ever discovered. The main was broken badly for two or three feet each side of the crater; and a new length was put in which completely covered the whole area of damage, as the broken portion was in the middle of a 9 ft. length of main. The job was so simple that there is nothing of special interest to communicate with regard to it. The pressure was reduced to level gauge for a time, in order to stop the escape of gas, as some difficulty was experienced in closing a large valve.

The date was May 2, 1916, about 10 p.m. It is interesting to note that had the Zeppelin continued on its line and dropped another bomb, it would probably have been in the middle of the works, over which the air-craft hovered for some time.

HARWICH.

The order given by the G.O.C. of this fortress to shut-off the supply in case of "threatened air-raid" was protested against, as sometimes the attacks never took place for some considerable time after the warning had been issued. It was therefore altered to shutting-off only in case of an actual attack. As these attacks only took place when no

warning had been given, it was not possible to carry out the order until after the event. As some light was needed after these affairs (more especially for the hospitals, the police, the doctors, &c.), the order was never really carried out. If a warning was given of aircraft being in the district, the pressure was lowered to about 10-10ths; so as to reduce lighting to a minimum. The great disadvantage of this, however, was that it actually gave the inhabitants a warning of the threatened danger. This meant a considerable number collecting in the streets, which caused great danger, as in all cases of air-raids the population have always suffered greater casualties from falling shrapnel than from enemy action.

The chief difficulty the Company had to contend with was the very severe lighting restrictions. The position of the works being directly in line with the entrance to the harbour, both the naval and military authorities were very harsh in their dealings with them. They did not allow the slightest amount of light from the works, and gave instructions to seal-up every crevice, with the result (as the retort-house is very old fasbioned and only hand stoked) that it was not possible to keep men working. This order was enforced until the Company appealed to the Home Office, who overruled the naval and military authorities. allowing a certain amount of ventilation, but only on condition that working ceased during the warnings. As in midwinter these warnings sometimes were of eight or ten hours' duration, this meant a serious loss to the Company, as it was necessary to keep the men at the works in case of being allowed to resume working. If the Company had not had a large storage plant they would not have been able to keep the supply going—in fact, during September, 1915, for ten nights they were forced to stop manufacture for over forty hours.

LINCOLN.

When the message "Take Air-Raid Action" was received the pressure was reduced to 3-10ths at the works. This served as an efficient warning to the district, and to a large extent ensured that no lights were visible. As a precaution, consumers were urged to shut-off at their meters when the lights went out (as they generally did); and the Corporation have not heard of any escape of gas or accident having occurred when the pressure was resumed at the "all clear" signal.

For several reasons it was considered preferable to leave a modicum of gas in the mains, although the authorities were anxious to have it shut-off altogether. The end they had in view was secured by the reduction of the pressure to such a considerable extent. It was obvious that something of the sort was necessary, as on the first raid night nearly every bedroom window was illuminated.

Although the city had many midnight visitors, and as an important munitions centre was supposed to receive their special attention, fortunately no bombs were dropped within the city. This was attributed to the absolute darkness that prevailed.

MARGATE.

Incidents caused by enemy aeroplanes affecting these works and district during the war were some eight in number.

In all cases where bombs were dropped in the vicinity of property, it was the practice to turn off the gas at the meter of any premises that were damaged, as gas escaping was strongly smelt thereabouts, and frequently services to premises or lamps had to be disconnected or plugged-off in the road. These were additional to any steps taken to deal with any house actually demolished, as the effects of bombs were felt over very widespread areas, and loosened joints by concussion, while inside pipes were pierced by splinters, shrapnel, &c. Where mains were smashed, these were temporarily blocked-up with wooden plugs, clay, &c., till daylight came, when reinstatement was undertaken. Services similarly broken were also rendered free from danger pending the first opportunity of being properly dealt with. Pieces of shell, &c., penetrated many of the lamp columns, and in several cases travelled right through, and pierced both sides in a lateral direction.

PETERBOROUGH.

There was only a single occasion during one of the earlier air-raids when, by order of the Commanding Officer, the gas supply was shut off entirely about midnight. It was turned on again about breakfast time, and very little inconvenience resulted.

NATIONAL GAS COUNCIL OF GREAT BRITAIN AND IRELAND.

Central Executive Board Meeting.

A MEETING of the Central Executive Board of the National Gas Council was held last Wednesday, the 28th ult.

It was reported that Sir Dugald Clerk's report had been forwarded to the Board of Trade, together with the covering letter which had been approved by the last meeting of the Board. Steps which it was proposed to take to draw the attention of other bodies to this matter were approved.

A letter from the Institution of Gas Engineers reporting on clauses 53 and 54 of the report of the Fuel Research Board on Gas Standards was discussed; and it was resolved to write a letter to the Board of Trade objecting to these clauses, and asking that a deputation from the Council might attend before the President, in order to state their views on the matter.

A communication from the Federation of British Industries as to the interpretation of clause 15 of the Electricity Supply Bill was considered; and it was decided to take further opinion on this matter. The steps which had been taken with regard to the Bill were reported, and the further course it was proposed to adopt was decided upon.

It was reported that the Council had been in communication with their legal advisers and Members of Parliament in connection with clauses in the Ministry of Ways and Communications Bill which affected the industry; and it was resolved that, if found desirable, further action would be taken when the Bill reached the report stage.

A draft letter to gas undertakings with regard to the returns of coal stocks at gas-works made to the Coal Mines Department was approved.

SOCIÉTÉ TECHNIQUE DU GAZ EN FRANCE.

Programme of the Victory Congress.

As already announced in the "JOURNAL," the Victory Congress of the Société Technique is to be held in Metz in July this year.

Meeting on the morning of July 4, members will consider the accounts for the past year, elect new members, and nominate seven members to the Committee for three years, as well as receive the report of the work of the Committee for the business year.

In the afternoon the Presidential Address will be delivered; M. Mirman, the Commissary of the Republic in Lorraine, and General de Maud'huy, Governor of Metz and Commandant Supérieur of Lorraine, honouring the assembly with their presence. The address will be followed by the presentation of various awards, including war diplomas, government medals, and the Society's prizes to members for papers previously read, and to deserving workmen and employees.

Saturday, July 5, will be devoted to the reports of the various Technical Commissions and to papers, concluding with a visit to the Metz Gas-Works. On the following day members will leave by special train for Strasburg, the gas-works and sights of which city will be visited on July 7. Facilities are also offered to any members desirous of proceeding to Mulhouse on July 8, where M. Ellissen will render any assistance required by members.

The Mayor of Metz has very kindly offered a large room at the Town Hall for the use of the Society. The Committee, with much energy in face of considerable difficulties, have made arrangements for special trains from Paris to Metz, and Strasburg to Paris, and also for the accommodation of members. Details need, however, not be given here, in view of the recent announcement of the Société Technique that, to their very great regret, they cannot on this occasion open the congress to members of the gas industries of allied countries.

NATIONAL ILLUMINATION COMMITTEE.

IN view of the imminent resumption of international co-operation in the study of questions connected with the art of illumination and the sciences related thereto, a meeting of the National Illumination Committee of Great Britain was held last Tuesday at the Institution of Civil Engineers, when vacancies in the Executive Committee, due to the decease of Mr. W. Duddell, F.R.S., and Prof. Silvanus P. Thompson, F.R.S., were filled. The Executive, with the Institutions represented, is now as follows: Chairman, Mr. A. P. Trotter (Illuminating Engineering Society); Vice-Chairmen, Mr. John Bond (Institution of Gas Engineers) and Mr. Kenelm Edgcumbe (Institution of Electrical Engineers); Hon. Secretary, Mr. Haydn T. Harrison (Institution of Electrical Engineers); Hon. Treasurer, Mr. W. J. A. Butterfield (Institution of Gas Engineers); Representatives on the Executive Committee of the International Commission on Illumination, Dr. Harold G. Colman (Institution of Gas Engineers), and Mr. Leon Gaster (Illuminating Engineering Society). The resumption of research work, &c., was considered; and a programme for further discussion at a meeting at an early date was settled.

ELECTRICITY SUPPLY MEMORANDA.

The first public appearance has taken place of Mr. J. W. Beauchamp, since being appointed Director of the Electrical Development Association. It was at a lunch; and after lunch he made a speech. From what he said, it is gathered he appreciates that the functions of the new Association have two sides—the obvious and the opposite, and some of the best work is, so we understand him, that which is covert. This depends upon the quality of the work. He does not fear that subscriptions will not flow in. What he is more concerned about is that there shall be an abundant supply of cheap apparatus; and he asks the manufacturers to provide for this by segregation of production and by standardization. There may be something in his proposals; but he will hear the flutter of papers from all manufacturing directions announcing that the costs of metals of all kinds, as well as human labour and energy, have gone up to such an extent that no amount of specialization and standardization on the part of manufacturers can effect a balance. Electrical apparatus will therefore still remain dear. He does not look upon super-stations (which will be costly now) and bulk supply as likely to produce such great electrical development as high diversity and load factors. But if the mass of the people regarded expenditure—initial and working—high for electrical operation before the war, what must they think now of the costs? Electricity purveyors cannot hope, however much they aspire to do so, to work miracles. According to "Meteor," Mr. Beauchamp's ideas are that the possibilities of growth are tremendous; and also that it is not the price per unit that matters so much as the all-in cost. It is evident that the first Director of the Electrical Development Association is possessed of the right spirit; and there is no doubt he recognizes the difficulties before him. It must have required a good deal of courage for a man to take on such a "job" at the present juncture.

Importance of Initial Installation Costs.

Mr. Beauchamp, according to the truthful "Meteor," stated that "for the small consumer it was not the price per unit that mattered so much." The price per unit matters considerably not only for lighting, but particularly for heating and power. In the same issue of the "Electrical Times" in which this statement appears a tabulated account is given of sample old and new tariffs. For lighting 6d. and 8d. per unit are quite common; for heating 1½d., 1¾d., 2d. and 2½d. (some of them with an additional percentage attached) are plentiful; and power at like and some higher prices is now inviting custom. For heating, only the very wealthy can be expected to pay anything like the prices named for 3420 B.Th.U. Even London electricity supply undertakings acknowledge the abandonment of numerous electric-heaters, which reaction has more than wiped-out the rush that was made for electric-heaters in company with gas-fires when people began to find that coal supplies were running short. Brighton is charging 7d. for lighting, and 1½d. to 1¾d. *plus* 40 p.ct. for power; Burton-on-Trent has increased its lighting and heating charges by 60 p.ct., and its power charges by 80 p.ct.; Darwen consumers now pay 8d. for lighting, and power has been increased by 95 p.ct.; the lighting charge at Dover is 6½d., heating 2½d., and power 3½d.; Gloucester charges have increased by 100 p.ct. all round; Hull by 67½ p.ct.; and Ipswich lighting by 75 p.ct., and heating and power by 80 p.ct. Leeds has gone up by 60 p.ct. in all branches. Quite a number of undertakings have made a 50 p.ct. move up; and we know some are still contemplating a further stride. We ask Mr. Beauchamp how he regards the heating prices as helping to promote his idea of placing heating and cooking appliances now? We ask him, too, whether he has given sufficient attention to present market prices of metals; and how current wages are going to help him? The task he has taken in hand is not by any means an easy one.

Electricity Price Increases.

We are sorry that "Meteor" does not like to assist in the propagation of the truth, though quite a virtuous thing to do. He calls to task Messrs. Tyler & Freeman, who are electrical contractors, for publishing a brochure, which he thinks is unlikely to do the cause of electric lighting any kind service. He objects to the gruesome warnings as to what may betide the householder as a result of scamped work. The pamphlet also compares prices of 1914 with those 1919; and "Meteor" describes the case as a dismal one, and agrees that the relative figures are certainly appalling. But he declines to quote the actual figures. He thinks the comparison is quite ephemeral; and this is his reason for refusing to help in the propagation of the information. The reason is not sufficient. Every electrical man knows how costs have gone up; and every householder with a fancy for an electrical installation has a shock when he learns the truth. It is no use trying to hide the matter; anybody can find out all about it by simple inquiry. We do not suppose for a moment that the crest figures for installation work will be permanent; but how much below the crest are they going to fall in the future? Labour comes in largely in electric installation costs; and it does so in the manufacture of the materials and appliances. Coal costs for all manufacturers are not going to return to their old levels; pig iron has gone up to a remarkable height; and metals of all descriptions show a strong resistance to any declension in price. For years to come the demand is likely to be prodigious. We cannot see where "Meteor" finds his justification for the use of the term "ephemeral." And as to the cost of electrical energy, the tabulated returns referred to in the preceding paragraph, do not suggest to us that it has only risen "in a moderate degree." However, perhaps "Meteor" is a wealthy man; and views on such subjects as these are sometimes fashioned by the measure of one's capacity to pay.

Are Present Installation Costs Ephemeral?

The Ministry of Reconstruction are not receiving the reward they expected for their pamphlet No. 24, which we recently noticed. It is too fantastical even for some electrical men. "Meteor" makes merry over it. "The British Government sees before it a gorgeous Utopia of peace, plenty, and contentment—thanks to electricity. It sees before it a vision of dirty towns made clean—by electricity; of juicy greenswards whereon frolics the spring-time lamb—clipped, combed, and disinfected by electricity." But "Meteor" pauses and thinks, which, as he makes special mention of it, is apparently an unusual thing for him to do. The result of his pausing and thinking is that he has doubts whether the electrical requirements of rural life will justify the flinging out of three-core lead sheathed feeders in every direction. The distances to be traversed are often formidable; and there is not much load to be picked up on the way—or even when you get there. Some of these little villages have their own installations. "If further progress in this direction be arrested, and if the electric supply authorities decide that these outlying villages in many cases must be the subject of mature consideration and careful thought, then we may take it the enthusiastic wording of Reconstruction Pamphlet No. 24 is mere poetry." This fairly describes, with good electrical origin, our own estimate of the pamphlet.

Electrical Estimate of Pamphlet No. 24.

Incidentally we have referred on a previous occasion to the experience of Belfast in regard to the rise in cost of extensions to the Corporation electricity station. It has been an awful shock to Belfast; and the subject of much discussion and explanation in the Council Chamber. When last we referred to the matter, it was in connection with the foundations and buildings only; but subsequent information shows that the whole cost of the extension will be £648,000, as against an estimate of £310,000. The cost is more than double; and as money is now of higher value, the capital charges will be more than double. As capital charges form a good half of the outgoings incurred in running an electricity station, the extension is not likely to contribute to a reduction of the charges for electricity. Sir John Snell (who is one of the partners in the firm of Messrs. Preece, Cardew, Snell, & Rider, and the Consulting Engineer for this scheme) has had some rather furious attacks made upon him in connection with the matter; and one of the Aldermen appears to have been anxious to have Counsel's opinion as to terminating the agreement with Sir John, and to ascertain his responsibility in the matter. The debate that took place on this proposal is described as having been a lively one; but there was rejection. Mr. Rider was a short time ago allowed to address the Council on the subject of the great difference in the cost. He candidly admitted that the cost of the buildings was put too low; but the greater reason is that the cost of everything has risen considerably since the estimates were made. Mr. Rider has not much faith now in estimates holding good for even a week. Pessimism has got a grip of him even in connection with his latest estimates of revenue and expenditure. If this is the case over a single station, what must be the condition of things in the matter of such a scheme, with all its ramifications, as the Government is mothering? But, it would seem from the report before us that Mr. Rider is either gambling in respect of the future or he possesses the gift of correct prediction. Time will tell. What he is reported to have said is that the Corporation are spending very largely on account of the future; and it is wise to do so, in order to avoid unnecessary excess expenditure at a later date, and the future will repay them for the present. Just previously there was the reference to his pessimism as to his own estimates regarding revenue and expenditure! His advice to the Corporation is to offer such a price to the shipyards and other consumers as will bring in customers—the more the better. But when quoting prices, the Corporation have to consider the matter with the view to keeping on the right side of the ledger. However, the firm's view as to how to lighten the immediate incidence of the costs is found in the recommendation to promote a Bill to authorize payment of interest on the new capital out of capital; and the suspension of the sinking fund during the period of construction. The Local Government Board, too, it is suggested should be asked to grant loans on the following conditions: 100 years for buildings, 60 years for foundations and river work, 25 years for plant, and 30 years for cables, or an equated period of 30 years for the whole. Whether Parliament and the Local Government Board will consider all this good finance remains to be seen.

The Enlargement of Capital Costs.

PERSONAL.

There was on Saturday a highly successful function at the Trocadero Restaurant, in the form of a dinner given by the engineering staff of the South Suburban Gas Company in honour of Mr. SYDNEY Y. SHOUBRIDGE, on his retirement after twenty-three years' service as Chief Engineer. The staff were fully represented; and the general tenour of the speeches which accompanied the toast list bore upon the good relations that had always subsisted between Mr. Shoubridge and those working with him. All regard him, not only as chief, but as a friend. After the toast of "The King" had been proposed by the Chairman (Mr. W. G. Waller), the "South Suburban Gas Company" was submitted by Mr. W. M. Judd, supported by Mr. H. Jeffery. That of "Our Guest" was confided to Mr. R. Fowler, supported by Mr. Bernard P. Bezant. Mr. Shoubridge, in reply, gave a résumé of the progress of the Company during his period of office—touching more particularly upon the great enlargement of the area of supply and the extensions and reconstructions that have been carried out in connection with the various works. He also referred to the great assistance received by him from all members of his staff, and said that he felt he was losing a good many friends by the severance that was about to take place between him and the official position that he had so long occupied. That he would be losing a good many friends was strenuously denied by the subsequent speakers, who declared that, wherever Mr. Shoubridge might be, they intended always to maintain their friendly relations with him. The toast of "Mrs. Shoubridge and Family" was submitted by Mr. W. Gosling, supported by Mr. H. C. Glass; and that of the "Future Deputy Engineer" (Mr. Frederic G. Gorman), by Mr. A. V. Hendrickson, supported by Mr. E. G. Dickinson. There will be a presentation to Mr. Shoubridge at a later date.

Mr. WILLIAM BELTON, who has been the chief officer of the Shrewsbury Gaslight Company for forty years, has just retired, and is, we understand, leaving the town to reside in the South of England. Mr. CHARLES M. D. BELTON has been appointed to succeed him in the offices of Engineer, Secretary, and Manager. The new chief officer, who is an Assoc.M.Inst.C.E., A.M.I.Mech.E., and a Fellow of the Chartered Institute of Secretaries—having already been with the Company for more than nine years—will, no doubt, enjoy the same confidence as was reposed in his predecessor.

Mr. ARTHUR BROMLEY, the Gas Engineer at Batley, has been appointed Engineer and Manager to the Keighley Corporation Gas Department, at a commencing salary of £450. There were 54 applicants.

On account of ill-health, Mr. ALFRED KITT has retired from the Board of Directors of the Waltham Abbey and Cheshunt Gas and Coke Company. He has been a Director for over thirty-five years, and Chairman of the Company since 1898. The Directors invited Mr. E. L. BURTON to a seat on the Board; and, on his acceptance, he was elected Chairman.

Sir ALBERT STANLEY, M.P., has, on account of ill-health, tendered his resignation as President of the Board of Trade; and Sir AUCKLAND GEDDES, K.C.B., M.P., has been appointed his successor.

Mr. JOHN GILLESPIE, a partner in the firm of Messrs. Andrew Gillespie & Son, of Glasgow, has been appointed Consulting Engineer to the Burmah Oil Co., Ltd., whose head office is in Glasgow. Mr. Gillespie's headquarters will be in London.

The "Daily Telegraph" mentions that, with the retirement in July of Mrs. CLARKE from the position of Principal of the National Training School of Cookery, comes the close of active service that has meant very much in our domestic well-being. Many gas-cookery teachers in the gas industry have passed through the hands of Mrs. Clarke, and will always remember with grateful appreciation her kindly words of counsel.

Masonic—The Evening Star Lodge and the Institution of Gas Engineers.

There was a large accession of guests at last Wednesday's meeting of the Evening Star Lodge, No. 1719, as the opportunity afforded by the annual meeting of the Institution of Gas Engineers was embraced by the members to invite all masons belonging to this body to be present at the regular proceedings, as also at the subsequent dinner. In the course of the evening, the Worshipful Master (W.Bro. H. W. Parkham, P.P.G.D., Surrey) made appropriate allusion to the presence of the Institution members, and gave all a hearty welcome on so interesting an occasion. At the banquet later in the evening, the Immediate Past Master (W.Bro. Fred. J. West) was accompanied by Bro. William Kay, the Lord Mayor of Manchester; while a long list of Provincial Grand Officers, present and past, also supported the Master in the Chair.

Fertilizer Orders Suspended.—The Ministry of Munitions has suspended the operation of the following Orders, which provided for the control of superphosphate, sulphate of ammonia, ground basic slag, compound fertilizers, and sulphuric acid: Fertilizer Prices Order, 1918; Compound Fertilizer Order, 1918; Sulphuric Acid Order, 1917; Sulphuric Acid (Amendment of Prices) Order, 1918; and Sulphuric Acid (Amendment of Prices) No. 2 Order, 1918.

COAL SUBSTITUTES FOR GAS MAKING.

MENTION was made by Mr. Charles Hunt, the Chairman of the Monte Video Gas Company, Limited, in the course of his remarks to the shareholders, at last Wednesday's meeting, of the receipt of an interesting letter from Mr. T. F. Lane, the Company's Manager in Monte Video, giving an account of his experiences in the carbonization of the substitutes to which he was driven by the impossibility of procuring an adequate supply of coal. During 1918, Mr. Lane carbonized no less than 5384 tons of wood, 390 tons of maize, and 49 tons of bran. The wood was made up of 2820 tons of quebracho blanco (white quebracho), 197 tons of quebracho colorado (red quebracho, the extract from which is used for tanning purposes), and 2367 tons of maritime pine.

MAIZE AND BRAN.

The maize and bran were carbonized in new through settings, to the extent of about 5 p.ct. mixed with the coal. An attempt was made to charge with maize only; but it clogged the charging machine so badly that the attempt had to be abandoned. Another great drawback to the maize was the tremendous flame which it gave off during charging, owing to the gas coming off so quickly. This made it almost impossible for the men to work, besides causing great loss of gas. In consequence of its burning-off so quickly, it was found, when charging more than 5 p.ct., that by the time the maize was completely carbonized the coal was still raw, which was equivalent to having a very light charge of coal in the retort, with the accompanying impoverishment of the gas. It also cleaned all the scurf off the retorts, thus exposing all the cracks, and causing a loss of gas, besides interfering with the working of the charging machine. The small percentage used did not affect the coke very much, though the separate grains of maize could be distinctly seen in the coke, which was more friable on this account.

The same remarks apply to the bran, with the additional inconvenience that, owing to its lightness, it was, with the slightest breeze, blown about everywhere.

THE MOST SATISFACTORY SUBSTITUTE.

Mr. Lane found the most satisfactory substitute for coal to be quebracho blanco, from Argentina. This was already cut into lengths of about 2 ft. 6 in. long, small enough in diameter, as a rule, to enter the retorts, though some had to be split-up. The retorts were filled as full as possible—charges weighing about 1½ to 2 cwt. being carbonized for six hours, at the end of which period the remaining charcoal still retained the form of the original wood, though occupying less than one-half the space. It fell into small pieces on being touched with a rake.

The quebracho colorado was only used as a stop-gap, when they were short of the other class, because it was said that it formed such a large amount of tannic acid as to seriously damage the plant in a very short time.

The maritime pine came from different parts of the coast. It gave fair results, which could no doubt have been improved upon had it been seasoned wood, and not green and full of moisture.

RESULTS OF CARBONIZING WOOD AND THE COST.

The wear and tear in carbonizing wood was found to be extremely heavy. The retorts had to be charged by hand, though the machine could discharge them if everything was well burnt-off. The gas given off by the wood, to the amount of some 10,000 c.ft. per ton, was about 360 to 380 B.Th.U. per c.ft., practically non-luminous, and very heavy, owing to the presence of about 26 p.ct. of carbonic acid. On account of being so acid, it caused trouble in purification, which difficulty was overcome by fixing up scrubbers between the retorts and the condenser. These scrubbers also arrested the tar, and prevented it going forward and clogging the mains. They were also very useful as condensers, as the gas, containing a large amount of water vapour, was very hot—198° Fahr. at about 100 ft. from the outlet of the hydraulic main.

The wood tar was so thick that it was imperative to fix tar-towers to draw it off as soon as possible. These towers had to be emptied twice a day, before the tar got too cold; otherwise it would not run at all. No sale could be found for the tar; so it was mixed with breeze and burned under the boilers. The wood took the scurf off the retorts so completely that it was necessary to charge a few shovels of coal along with it, to form a little scurf to keep the retorts as gas-tight as possible. There was no charcoal for sale, as the furnaces required practically all that was made; and even then the heats were not by any means high.

On the financial side of the question, Mr. Lane says the cost of working wood is very high indeed in comparison with coal, as it has all to be dealt with by hand, piece by piece; and it is so bulky that it occupies about three times the space of coal, unless neatly packed, which operation is also costly. The cutting-up is expensive; and the carbonization cost is very heavy, being $1.87 per ton for wood, as against $0.77 per ton of coal. Both these figures include all charges from store to coke-yard.

Many other materials were experimented with; but those mentioned in the letter were found to be the most suitable, though, Mr. Lane says, none of them can be compared with coal.

An application for an Order under the Statutory Undertakings (Temporary Increase of Charges) Act has been received by the Local Government Board from the Skipton Urban District Council.

CONTINUOUS VERTICAL RETORTING ON THE "DEMPSTER-TOOGOOD" SYSTEM.

Messrs. Robert Dempster & Sons, Ltd., of Elland, have prepared an elaborate coloured illustration of the working of the plant to carry out the above-named process, which is protected under patent No. 19,971 of 1915.

In regard to the matter, they remark as to the great benefit possessed by the system with the intimate, continuous, and steady steaming of the charge, whereby over a period of nine months in a Lancashire works the results have been increased as follows:

From 15,804 to 22,260 c.ft. of gas per ton of coal = 41 p.ct. increase.
From 8,028,000 to 9,939,260 B.Th.U. per ton of coal = 21 ,,
From 14·15 to 20·10 gallons of tar per ton of coal = 42 ,,
From 30·60 to 37·00 gallons of 10 oz. liquor . . . = 24 ,,

It is in order to enable one to visualize both the chemical and the physical processes occurring simultaneously within the retort, that the firm have arranged the coloured lithograph so as to portray the coal passing successively through every conceivable zone of temperature. The charge in the system in question opens-out into ever-increasing cross-sectional areas of the retort; the maximum cross section resting actually upon the moving mechanism, whereby ever-fresh surfaces of incandescent carbon are offered to the rising and expanding volumes of superheated steam and water gas. This hot scavenging medium entering among the interstices of the incandescent coke, directly conveys heat units into the innermost cores of the coke—thereby releasing imprisoned volatiles to a greater degree than heretofore, and ensuring the coal gas yields being retained at the highest.

Simultaneously, the coal on distillation yields its coal gas direct into a hydrogen atmosphere, whereby the hydrocarbon vapours are not split into scurf, pitch, and naphthalene compounds, but are carried forward to enrich the residual yields, to permit of legitimate dilution to economic advantage, and to maintain gas of excellent composition and flame temperature.

The drawing also sets forth the many patented features characterizing the "Dempster-Toogood" system, which applies or develops the principle of continuous retorting to a greater degree than the earlier systems—particularly in the automaticity of working, which after all is where the charm and efficiency of continuous retorting lies. Also the fact that the coke is discharged cooled permits of the stokers' work being rendered much less arduous and more humane—so much so that six stokers have over five winters, regularly and with comparative comfort, produced 1,000,000 c.ft. of gas per diem with the system.

LONDON AND SOUTHERN JUNIOR ASSOCIATION.

There was a well-attended meeting last Friday evening, at the Westminster Technical Institute, Vincent Square, S.W., of members of the London and Southern District Junior Gas Association, with Mr. S. B. CHANDLER (the President) in the chair.

The PRESIDENT, at the opening of the proceedings, remarked that the Council considered it desirable to present to the members a brief account of their stewardship since the last annual general meeting held in May, 1916, when it was resolved to hold one meeting only during the 1916 17 session, in view of the difficulty of carrying on in the face of existing circumstances. This meeting duly took place, when Mr. J. Hewett, a member of the Council, gave an interesting paper on "Combustion Methods in the Laboratory," followed by a discussion on "Salesmanship and Examinations." It was not found possible to arrange a programme for the 1917-18 session; but Mr. W. Newton Booth, of Woolwich Arsenal, delivered a lecture on "Some War-Time Lessons for the Gas Industry," which formed a valuable addition to the Association's "Transactions." With that evening's meeting, and a visit to the Hampton Court Gas-Works, on June 28 (by courtesy of Mr. W. E. Price, the Engineer and Manager) the present session would close. Now that the war had terminated, and the period of stress was rapidly passing, the Association would once again go ahead and resume normal activities; and the Council anticipated arranging a session full of interest during 1919-20, in connection with which four papers had already been promised. At the close of 1916, the membership was 185; and at the present time it stood at 179. So far as the records showed, fifty members had joined the forces, of whom unhappily four had given their lives. During the war period the subscription was reduced to 2s. 6d.; active service members not being required to contribute. This will revert to the old scale of 7s. 6d., as from the forthcoming session. The Hon. Treasurer had in course of preparation a balance-sheet which would be presented to the members in circular form at a later date. The Junior Gas Associations, lately established as a body the principal object of which was to further technical education (now indispensable to all who wished to qualify for the higher ranks of the industry), and which had been called upon to supply teachers and examiners in gas technics, had been for some time in negotiation with the Institution of Gas Engineers upon the question of examinations in the gas industry. As a result of this, representatives of the Joint Council had been appointed—of whom he had the privilege to be one—to take up the matter, and present the views of the Junior Associations to a Committee of the Institution, by whom the representatives had been most cordially received upon the two occasions when conferences had been held. The sympathetic consideration afforded by the President and Council of the Institution had helped matters very considerably; and the representatives hoped to materially assist in furthering a scheme having so important an application.

HOUSING SCHEMES AND COLLECTION OF DATA.

The business of the evening consisted in two good discussions, which it is unfortunately, owing to the great demands on our space, impossible to report in this week's issue. The first was opened by Mr. W. L. WESTBROOK, of the North Middlesex Gas Company, and was on the subject of Gas Installations for Housing Schemes, in connection with which he made suggestions for securing efficiency. The other—entitled "Some Observations on the Need for Closer Comradeship between Works, and Collective Information of Working Results"—was opened by Mr. D. C. CROSS, of the Lea Bridge District Gas Company.

A hearty vote of thanks was accorded Mr. Westbrook and Mr. Cross, on the proposition of Mr. J. W. COLMAN, of the North Middlesex Gas Company, seconded by Mr. W. H. ASKER.

During the proceedings refreshments were provided by the President.

A NEW PRIME MOVER.

The Still Internal Combustion Engine.

Before the Royal Society of Arts yesterday week, Mr. F. E. D. ACLAND, M.Inst.C.E., read a paper entitled a "New Prime Mover of High Efficiency and British Origin," in the course of which he described the Still engine. The paper was a very long one, accompanied by several diagrams; and it is not possible to do more than give a few extracts from it. The underlying principle of the system described consists in raising steam from the heat now lost in the jacket water and the exhaust. In the Still engine, the steam is expanded in the internal combustion engine at the back of the main piston; one stroke being performed by the steam pressure, and the other by the combustion pressure. There is no loss by condensation. The steam is said to be used under conditions more favourable than those of any steam-engine since its invention; for it picks-up heat during its expansion stroke from surfaces of necessity hotter than itself. The results—many of which have been supervised by Prof. C. Vernon Boys, F.R.S., and the late Lt.-Col. W. Watson, F.R.S.—show at present a fuel efficiency at least 20 p.ct. above any type of prime mover; while all the advantages of steam (including compounding and condensing and capability of starting, manœuvring, and overload) have been added to the engine.

The maximum ideal efficiency of a heat engine, Mr. Acland said, is obtained where the difference existing between the highest and lowest temperatures of the working fluid is greatest in proportion to the maximum temperature; and here the internal-combustion engine, with an initial temperature higher than the furnace temperature of a boiler, and even higher than the melting-point of cast-iron, is capable of realizing better thermal conditions than any other form of heat engine. But, in its turn, it suffers from two disadvantages—it ejects its working fluid at a temperature too high for ideal conditions, and it loses heat energy to a regrettable extent in the cooling of its cylinder. The result obtained in practice from the two cycles separately, based on their best performances after half-a-century of intensive development, is that in the steam-engine there is a loss of over 80 p.ct. of the heat contained in the fuel, and in the combustion engine of 60 p.ct. The recovery and efficient use of the waste has been the work of many years of patient research by William Joseph Still and others associated with him, and has resulted in the design and construction of a variety of engines which bear-out the correctness of his principles, and point to a vast field of further practical application. The possibility of combining in one engine the superior thermal cycle at the high temperatures and pressures of the combustion engine with the low thermal cycle of steam to deal with its rejected heat, and, in the same engine, add the superior working advantages of the steam-engine, was the basis of his work.

The Still engine is an engine capable of using in its main working cylinder any form of liquid or gaseous fuel hitherto employed. It makes use of the recoverable heat which passes through the surfaces of the combustion cylinder, as well as into the exhaust gases, for the evaporation of steam, which steam is expanded in the combustion cylinder itself on one side of the main piston—the combustion stroke acting on the other side. It increases the power of the engine, and reduces the consumption of the fuel per horse power developed. Its primary object is not to use the waste heat for raising steam, but first to use it in improving the thermal conditions of the working cylinder, and so ensure the maximum efficiency from the fuel burnt within it—diminishing, as a consequence, the heat lost in the operation. Since the maximum efficiency is obtained by combustion of the fuel in the cylinder, and the minimum by the evaporation of the water in the steam generator, it is evident that the larger the quantity of steam which can be generated per horse power developed by the combustion cycle, the lower must be the heat efficiency of the whole machine.

Internal-combustion engines are kept cool by the circulation of cold water round the cylinders. The heat thus absorbed causes a

rise in temperature of the water as it travels through the jacket, so that the cylinder is subjected to temperature differences and heat stresses which are an abiding source of trouble and difficulty to the designer. In the Still engine, the jacket and cooling water form part of the circulating system of a steam-generator, which may be an integral part of the engine or external to it. The cooling water therefore enters and leaves the jacket at a constant temperature, regulated by the pressure of the steam; the cooling being effected by converting the water into steam without raising its temperature. Excluding the radiation losses, which are kept low by lagging, all the heat which passes through the walls is thus usefully recovered in the water as steam. The temperature of the cylinder wall is uniform over the whole of its exterior surface; and the heat lost to the cooling water at each stage of the cycle—compression, combustion, and expansion—is diminished.

During compression, owing to the walls being at steam temperature, the incoming charge picks-up heat, instead of losing it, during the greater part of the stroke. During combustion and expansion, the uniform and higher mean temperature of the walls reduces the heat lost to the jacket water. Some of the heat thus economized adds to the useful work on the piston; the balance passing-out in the exhaust gases for recovery.

To ensure the maintenance, in a practical and reliable manner, of the temperature conditions which produce this efficiency during the combustion cycle, a departure from the design and construction of the cylinders of normal internal combustion engines is imperative. They have hitherto been made of cast iron, of a thickness sufficient to resist the working and thermal stresses thrown upon them, including occasional heavy loads caused by pre-ignition of the explosive charge. With these thick walls or liners, the temperature difference between their inner and outer surfaces, which is essential if the surplus heat is to be carried off, can only be obtained safely by the circulation of water at low temperature through the jacket. This is especially the case in cylinders of considerable diameter, or capable of high power per swept volume.

The cylinder of a Still engine consists of an inner liner, which is approximately one-third to one-fourth of the usual thickness. It is ribbed externally, so as to add to its conducting surface and provide suitable passage for the cooling water; and it is reinforced by an outer hoop capable of withstanding the highest pressures to be met with in working. The stresses due, in ordinary practice, to the cold water at the inlet, and the hotter water at the outlet, are suppressed in the Still cylinder; the cooling water being at a controlled and uniform temperature throughout.

No failure of a cylinder of any kind has occurred, even under most severe, even abnormal test conditions—*e.g.*, with mean combustion pressures of 180 lbs. per sq. in. in a two-stroke engine—to which was added overload steam mean pressure of 70 lbs.—*i.e.*, a total M.E.P. per revolution of 250 lbs. per sq. in.

In gas and oil engines of constant volume and constant pressure types, the combined losses in radiation—cooling water and exhaust gases—range between 75 and 65 p.ct. The highest indicated thermal efficiency claimed under test conditions with a Diesel engine—Mathot—300 B.H.P., four-stroke at three-quarter load, is 47 p.ct. (36 p.ct. brake efficiency). If 4 p.ct. is allowed for radiation, 49 p.ct. of the total heat is available for recovery; and if 10 p.ct. efficiency is assumed for the steam cycle, the brake thermal efficiency of an engine giving this high result would be raised by 10 p.ct. of $49 = 4{\cdot}9$, *i.e.*, $36 + 4{\cdot}9 = 41$ p.ct. But there is no reason why the steam generated and used under the conditions of the Still system, should be limited to so low a figure. A more reasonable assumption is 15 p.ct.; and even a higher figure may be anticipated, in which case a brake thermal efficiency of 44 p.ct. should be possible in a complete installation. Such a statement can only be warranted by realizing the method by which steam is produced and used in the engine.

This the author then proceeded to describe; and he then gave some notes on gas, petrol, and oil engines that have been made. As to gas-engines, he said that the first experimental engine constructed was a two-stroke engine capable of developing 590 B.H.P. from three cylinders at 400 revolutions, bore 8 in. It was a high-speed engine, designed with special regard to obtaining data about the recovery of steam from waste heat (jacket and exhaust). It was first operated on town gas—540 B.Th.U.—and subsequently converted for oil fuel. Its efficiency was not high, owing to its being a two-stroke engine with a short stroke; but its consumption per B.H.P. was 15 c.ft. per hour (31·3 p.ct. efficiency), a very promising result.

The outbreak of war prevented much progress being made in the design and construction of these gas-engines; but the results achieved give great promise of future development, for with a combustion indicated efficiency of 36 p.ct., radiation 4 p.ct., boiler loss 10 p.ct., there remains 50 p.ct. for recovery. Allowing 10 p.ct. efficiency for the steam cycle, a gain of 5 p.ct. is assured; and the total indicated efficiency of the engine will not be less than 41 p.ct. If 20 p.ct. efficiency is obtained from the steam cycle, as appears possible, the total indicated efficiency will be 46 p.ct. A gas-engine which can give a brake thermal efficiency 30 p.ct. better than its predecessors, and which, by governor control alone, can meet any demand up to and over 100 p.ct. overload, while maintaining a good efficiency at this increased output, cannot be neglected.

In November, 1916, at a meeting of the Royal Society of Arts, Sir Dugald Clerk, F.R.S., read a valuable paper in which he alluded to the important part taken by Britain in the origin and development of steam motive power as being acknowledged as supreme; and he emphasized the leading part—not perhaps adequately recognized—which this country can claim in the great field of invention covered by internal-combustion engines, in which he himself has been a leading contributor, and to whose work and writings all students of the art and engineers are under deep obligations. In mentioning the attention devoted by German designers to gas and oil engines of large cylinder dimensions, he contrasts the attitude of English engineers by stating that "from the scientific point of view, they consider that the building of large engines, practically without modification of either thermodynamic or operative cycle, is a costly mistake, leading to a development in the wrong direction," and that "other methods must be found of increasing power in internal-combustion engines than mere increase of cylinders and massive construction of the engine parts as practised in Germany."

It is true that this country cannot yet claim great installations capable of 80,000 H.P., such as exist at Gary, Indiana, where they have, with constant reliability and fine efficiency, proved their usefulness. But here, at this crisis, no possible source of cheaper power can be neglected. It is disappointing to read in the report of the Fuel Research Board formed by the Privy Council Committee for Scientific and Industrial Research, that the gas-engine, with its great possibilities and undoubted potentiality for improvement, both thermodynamically and in its operative cycle, is not alluded to; and the only source of power suggested for the countless millions of cubic feet of gas which are now still running to waste, and whose volume will be enormously increased when our coal supplies are more reasonably used, is by burning it under boilers for raising steam. The thermodynamic cycles and the improved cylinder construction now submitted, enable more powerful installations to be designed, and promise a substantial increase to their efficiency.

Great improvements have lately been made in gas-producers, some of light weight, which answer automatically to all variations of load. The addition of a steam cycle to gas-engines, operating with these producers, will give a means of manœuvring and starting which will fit them for service as marine engines and locomotives for road or rail.

Improvement in Gas Incandescent Lighting.

According to the "Official Review of the Foreign Press—Technical Supplement," Dr. Allner, who has made a study of the influence of gas pressure and the form of the orifice of a burner on the indraught of air and the production of light, suggests improvements of considerable importance both to the gas industry and to the consumer. He finds that the width of the magnesium orifice of the burner has a marked effect in the case of hanging lamps. As an inference for practice, coal-gas with an addition of water-gas needing but a small air supply, requires only a narrow orifice. By this simple means, says the "Journal für Gasbeleuchtung," the cause of many complaints of the imperfect action of the burner may be removed.

Preparing Lubricating Oil for Re-Use.

During the war, when lubricating oil sold at very high prices, and internal combustion engines made by them for special purposes had to be subjected to long and hard endurance runs at full speed, the Midwest Engine Company, of Indianapolis, put in operation a process of reclaiming the used oil, a description of which has appeared in the "American Gas Engineering Journal." They found themselves with some hundreds of barrels of these high-priced lubricating oils, contaminated by carbon, gasoline, water, metal filings and chips, and miscellaneous dirt; the oil being unusable because filters failed to clean it sufficiently, and because there were no means available to separate the water and lighter oils from the lubricating oil. The plant which was eventually designed and successfully employed for the purpose used gas for fuel. Briefly, the method was as follows: The oil was collected in barrels, and permitted to remain as long as possible, to deposit by gravity the grit and foreign matter. It was then drawn-off down to the settlings and placed in reclaiming tanks over gas-burners; the water and lighter oils being thus driven off. This heating agitated the oil, made it lighter, and therefore produced rapid separation of the carbon, grit, and other foreign matter which still remained in suspension. A critical point in the process was the boiling and agitating of the oil in the tanks, which, if unrestrained, would have meant the overflow of the oil. When at irregular intervals the oil reached this agitated condition, it was kept under control by playing a gas-flame from a torch on the top of the oil. A complete analysis of the reclaimed oil is almost identical with its analysis when new. In the process no other fuel was found so safe and convenient as gas. In fact, gas seemed to be necessary to the success of the process.

A gas well of an estimated capacity of 2,000,000 c.ft. a day has been brought in on Gas Ridge, five miles west of Kelly Field, by the Wisconsin-Texas Gas Company. This is the second well brought in on this tract by the Wisconsin-Texas Company, who have let contracts for the drilling of fifty gas wells and four deep wells for oil on Gas Ridge.

CORRESPONDENCE.

[We are not responsible for opinions expressed by Correspondents.]

Professor Smithells and Last Week's Discussion on "The Education of the Gas Engineer."

After our report [*ante*, pp. 582-588] of the discussions at last week's Institution meeting had been made up for press, Professor Smithells forwarded the following written reply to the remarks made on the Education Question.

In general reply to the discussion at the meeting, I should like to say that I admit to having narrowed my remarks to the question of scientific training. I hope it may not be supposed that I underrate the importance of the human and personal factors in education and in the conduct of affairs. To me, the part of education which seems above all else precious to the individual, and of fundamental importance to our national character, is that all-round training of the whole man, the expansion of mind, broadening of sympathies, comprehension of human nature, habituation to give and take and to rule and be ruled, which, as Mr. Goulden observed, come to life in a well-ordered University community. These are things largely achieved outside the class room and independent of pure intellect; but they are surely to be esteemed above all else that a University can give. And in relation to this, I should like to say that, in using the phrase about Germany, which Mr. Goodenough has justly criticized, I was thinking, among other things, of the Technical High Schools, the "Charlottenburgs," which, in the last generation, the Germans have favoured at the cost of their older Universities. It is precisely because of the restricted range of outlook in the design and life of these "efficient" modern creations that I have always pleaded for a close association in this country of applied science with all other liberal education. I am as eager for breadth as for depth in our educational institutions. I assent with the utmost readiness to Mr. Goodenough's suggestion that the lack of interest in studies may be largely the result of the teacher's attitude. It is only too true. We teachers need constantly reminding that we must interest our students if we are to make headway. We should remember that the intellectual appetite needs stimulus, and that the exceptional interest we ourselves have in abstract study must not be expected from the whole of mankind. The cost of University education is undoubtedly a serious consideration. One way or other it must be met; and I feel confident that, either by the lowering of fees or by the provision of scholarships on an ampler scale, it will be met until the nation is in the position of fully utilizing its intellectual capital. I am not prepared to admit that my prescriptions are a counsel of perfection. I consider them to express an urgent practical necessity that must be faced without delay. Undoubtedly the charge lies against the academic world of having adopted a disdainful attitude towards industry. I can only hope that the modern Universities situated in great centres of manufacture have done much, and will do still more, to destroy intellectual snobbery and keep themselves free from the influences that tend to indolence or enervation. In my opening remarks, I refrained from giving special prominence to the University of Leeds; but it is hardly right that I should fail to allude, as I now do, with more gratification than I can well express, to the harmonious co-operation which has been established through the Livesey Chair, the Advisory Committee, and our Joint Research Committee, between the gas industry and a centre of scientific work. I believe it affords an example that may be of great moment in the future organization of industrial science.

Mr. Samuel Glover's Remarks on Steel Tubes, &c.

Sir,—We notice that Mr. Glover, in his Presidential Address to the Institution of Gas Engineers, states that "evidence is accumulating of the persistent tendency to disintegrate which is inherent in some of the stuff called steel used for rolling-down into gasholder sheets, thin plates out of which tubes are made, &c."

We should be glad if you would allow us the opportunity of pointing out that such a remark cannot apply to our tubes, as these are not made from thin plates at all, but from the solid billet, and of a good class steel, which has already stood the test of time.

The British Mannesmann Tube Company, Ltd.
A. C. Williams, Joint Manager.

Salisbury House, London Wall, E.C.2.,
May 31, 1919.

APPLICATIONS FOR PATENTS.

[Extracted from the "Official List" for May 28.]

Nos. 12,503—13,141.

Aird, K.—"Boiling-rings, &c." Nos. 12,876, 12,877.
Aird, K.—"Combined stop-cock and gas-regulator." No. 12,878.
Allan, H. L.—"Atmospheric condensers." No. 12,652.
Beswick, W.—"Working of gas-producers." No. 13,123.
Bildt, C. K. E.—"Producer-gas furnace." No. 12,923.
Bradshaw, R. A.—"Valve-mechanism for controlling lighting of gas." No. 12,832.
Brayshaw, E. R. & S. N.—"Furnaces." No. 12,747.
Cade, E. B.—"Liquid meters." No. 12,663.
Chalmers, R. B.—See Aird. Nos. 12,876, 12,877.
Jennings, A. L.—"Apparatus for washing coke, &c." No. 12,983.
Johnson, J. Y.—See Allan. No. 12,652.
Matthews, J.—"Coin-freed gas-meters." No. 12,856.
Morgan, F. J.—See Bradshaw. No. 12,832.
Pilkington, W.—"Interchangeable gas-heated boiling pan and oven." No. 12,264.
Rambush, N. E.—See Beswick. No. 13,123.

PARLIAMENTARY INTELLIGENCE.

HOUSE OF LORDS.

Progress of Bills.

The South Shields Gas Bill received the Royal Assent.

The Dover Gas Bill was read a second time.

The Sheringham Gas and Water Bill was read the third time, passed, and sent to the Commons.

The Hartlepool Gas and Water Company have petitioned to be heard against the West Hartlepool Corporation Bill.

The Newark Gas Bill was read the third time, passed, and sent to the Commons.

The Northampton Gas Bill was reported with amendments.

HOUSE OF COMMONS.

Progress of Bills.

The Newark Gas Bill was read the first time, and referred to the Examiners.

The Edinburgh and Leith Corporation Gas Order Confirmation Bill was presented by Mr. Munro, and passed through its various stages.

The South Yorkshire Joint Lines Committee and the Midland Railway Company have presented petitions against the Swinton and Mexborough Gas Board Bill.

The Examiners reported compliance with the Standing Orders in the case of the Sunderland Gas Bill.

The Sheringham Gas and Water Bill was read the first time, and referred to the Examiners.

Miners' Hours and Coal Output.

Sir A. Geddes, replying to a question by Major Newman, said that the reduction in the output of coal that would be entailed by the reduction of working hours was estimated in the Sankey report at about 10 p.ct. The modifications that might have to be made in the Household Fuel and Lighting Order to meet the shortage of coal during the coming winter were now under consideration.

Mantle Import Prohibition.

Colonel Wedgwood asked the President of the Board of Trade whether the manufacturers of gas-mantles were asking for two years' prohibition of imports; whether any understanding had been given that this would be done; whether he was aware that the shares of the principal Company concerned had risen by 20s. a share in the last week, and were now thirty-four times the value they were in 1914, while mantles had risen from 1½d. and 2d. each to 8d. and 9d. each; and whether this form of protection was the considered policy of the Government.

Sir A. Geddes, who replied, said that he had heard of no such request as that indicated. Certainly no undertaking had been given about imports of gas-mantles after Sept. 1. He was unable to trace any share movement of the nature indicated. Colonel Wedgwood appeared to be comparing the pre-war wholesale price of mantles with the post-war retail price. Action so far taken was in accordance with the policy announced for the transitional period.

Proposed Change in the Method of Charging for Gas.

Major Prescott asked the President of the Board of Trade whether he could state the intentions of his Department with regard to the report of the Fuel Research Board on Gas Standards, which recommended a change in the method of charging for gas, and whether the proposed change, if given legislative effect to, would be ultimately inimical to the interests of gas consumers.

Sir A. Geddes (the Minister of Reconstruction) replied that the report was under consideration by the Board of Trade and other Departments concerned, and he could not state at present what action would be taken upon it. The Fuel Research Board, in making their recommendations, appeared to have given full consideration to the interests of gas consumers; and they would be safeguarded in any Bill which the Government might introduce to give effect to the report.

PRIVATE WAGONS AND THE TRANSPORT BILL.

The question of the purchase of private railway wagons was under discussion in the course of the proceedings of the Standing Committee on the Transport Bill last week.

Mr. Marshall Stevens worked out that there were between 700,000 and 800,000 such wagons. At £100 each they would cost £70,000,000 to £80,000,000. The Minister could not take one coal wagon without taking all; and this would commit the country to a minimum expenditure of £30,000,000.

Mr. Neal said that the matter had not been considered by the House; and if the clause was embodied in the Act the Minister would be able to go to the House and say: We are pledged to purchase, and all you may discuss are the terms to be imposed on the vendors.

Sir J. Fortescue Flannery was afraid that if the rolling coaling stock of gas companies was interfered with it might, in view of the possibility of official maladministration, lead to chaos and catastrophe.

Mr. Neville Chamberlain said that, in the case of the Birmingham Corporation's gas undertaking, taking over the wagons might lead to the holding-up of the gas supply. He did not see why the country should be asked to lock up many millions of money in this way without deriving any possible advantage.

Sir F. Hall protested against the absence of Sir Eric Geddes when such an important matter was being discussed, and moved to report progress.

The Chairman, however, refused to accept the motion.

Mr. Shortt (the Home Secretary) claimed that, in shunting alone, the pooling of wagons during the war had saved £3,000,000 a year.

MISCELLANEOUS NEWS.

MONTE VIDEO GAS COMPANY.

An Increased Dividend.

The Ordinary General Meeting of the Company was held last Wednesday, at the London Offices, Dashwood House, New Broad Street, E.C.—Mr. CHARLES HUNT (the Chairman) presiding.

The SECRETARY (Mr. Henry Kearns) read the notice convening the meeting; and the report and accounts were taken as read.

The CHAIRMAN, in opening, recalled the fact that the extent to which their dividend had suffered during the war had been a fall from 4 to 3 p.ct. Now, however, he said, they were in a position to offer the shareholders a larger dividend than the Company had been able to declare for many years. This might be regarded as a not unfitting rounding off of a situation, which, so long as it lasted, was one of constant difficulty, and even danger, to the undertaking. There had been a great scarcity of coal, which had not yet come to an end; and the Company were fortunate in having a Secretary like Mr. Kearns. It was mainly due to his perseverance that the Company eventually succeeded in obtaining recognition of their coal requirements. But it was a very near thing; and had it not been for the substitutes for coal which, on the very first note of danger, Mr. Lane (the Company's General Manager) at the request of the Board, pressed into service, it would not have been possible to tell the shareholders now that the supply of gas was fully and uninterruptedly maintained throughout the whole period of the war. These substitutes consisted chiefly of wood, bran, and maize, of which a considerable tonnage was carbonized in 1918; and a recent letter from Mr. Lane related his experience of them.* It was not suggested that the quality of the gas supply was at all times fully maintained throughout this difficult period; for this was impossible with the material at command. But an average reduction of about 10 p.ct. in calorific value—namely, to about 450 B.Th.U., did not prove to be any hindrance to its greatly increased use. In this respect, their experience seemed to have confirmed the almost universal experience at home, where 400 B.Th.U. was now being spoken of as a probable general standard, having regard to the recent recommendations of Sir George Beilby's Committee. This was 20 p.ct. less than their own self-imposed standard of about 500 B.Th.U., when using all coal. The consumption of gas last year was the largest ever experienced by the Company, and, with the returns already to hand for the present year, encouraged the hope that gas for heating and cooking might at last have come to its own in Monte Video. This was a development which had continually engaged the attention of the Directors; and everything possible had been, and would continue to be, done to further it. Increases, however, at the rate of 20 or 30 p. ct. could hardly be expected to continue for any length of time; and, if they did, it would be rather embarrassing now, seeing that the provision of additional manufacturing and storage plant would be an extremely costly matter, involving the Company in a permanent addition to capital charges probably three times as great as in ordinary times. Apart from mains, services, meters, &c., no additional plant had been provided during the past year; and it spoke well for the resources of the management at Monte Video that so large an increase in the consumption of gas as 27·49 p.ct. for the year had been met without any such extension, while at the same time it followed that the capital expenditure in proportion to gas sales was now the lowest on record. Perhaps the most conspicuous feature of the balance-sheet was the improved financial strength it indicated. The sundry debtors had increased by £6194, investments by £4934, and cash by £66,517. The loan of £9500 from the bank had been liquidated; but sundry creditors showed an increase of £33,205, and stocks of materials were valued at £20,106 less. There remained to the good, as compared with the figures for the previous year, upwards of £51,500, or £33,500 net, after deducting for the pension fund and deferred maintenance. The turnover of the undertaking had greatly increased, partly by reason of higher prices, but partly also, because of the larger volume of business transacted. This increase, as compared with the previous year, was about £51,000, while compared with the last pre-war year (1913) it amounted to about £94,000, or upwards of 74 p.ct. The trading profit, however, had by no means increased in proportion—in fact, as against 1913, there was an actual decrease of £5730. This comparison was incomplete without taking into account the profit on exchange, which this year amounted to £25,121, as compared with only £328 in 1913, and £1434 additional interest. This brought up the balance of profit for 1918 to £45,277, as compared with £34,518 for 1913. Hence, they found themselves in the agreeable position of being able to recommend the substantially higher final dividend of 3½ p.ct., which, in conformity with what was fast becoming a general practice, it was proposed should be paid free of income-tax. It was hoped the shareholders would agree with the action of the Directors in setting aside out of the profits of the year the sum of £5000 as a first contribution to a pension fund. The Board had long felt the necessity for such a fund; and it was a great pleasure to feel that there was now a prospect of being able to discharge what was really an obligation to those who rendered the Company long and faithful service. The comparison with 1913 showed the progress which had been made by the undertaking under war conditions; but actually the improvement was mostly due to the exceptional activity of the last year or so—1918 having been a record year in both branches of the Company's work. The business of the gas department was no doubt favoured by the great scarcity of both coal and oil throughout the whole of last year; but a part, at any rate, of the success was, he thought, to be attributed to what might be called the inherent stability of a gas undertaking, when left to its own resources and governed by the sole desire to stand well with its consumers. To all appearances, the condition of this undertaking was practically hopeless when, greatly overburdened with capital, it was some years ago confronted with the competition of a well-managed State-owned electricity undertaking. From that day, it was true, its lighting load was a vanishing one; but this was now much more than replaced by fuel value. The Board were, however, and always had been, impressed by the necessity of selling gas at the lowest practicable rates, consistent with all the circumstances. It was in this view that some years ago the price for heating and cooking was reduced by 2 c.—namely, to 6 c. per cubic metre, and that for lighting to 8 c. These differential rates were abandoned, owing to the war, in 1916; and for over two years a flat-rate of 9 c. per cubic metre had been charged. This was only 50 p.ct. above the pre-war price for heating purposes; while the cost of coal and freight averaged last year £7 9s. 1d. per ton, as compared with £2 3s. 8d. in 1913, or 240 p.ct. more. It was quite true that the cost of freightage had become much easier since the beginning of the year; but unfortunately that of coal had advanced considerably. In pursuance of their general policy, however, the Board would certainly reduce the price of gas as soon as practicable. He concluded by moving the adoption of the report and accounts.

Mr. JOHN MEWS seconded the motion, which was unanimously carried.

A dividend was declared for the past half year of 14s. per share (free of income-tax), making with the interim dividend 5 p.ct. for the year; and the retiring Directors (Messrs. John Mews and Charles Hunt) and the Auditors (Sir Laurence Halsey and Mr. W. C. Sneath) were re-elected.

Mr. MALLET, in proposing a vote of thanks to the Manager, the Secretary, and the staff, said he had just returned from Monte Video. There was prosperity to be seen everywhere there; and the town was extending in all directions. Mr. Lane was not only a good Manager, but he was very popular out there; and the advancement of the undertaking was due to a large extent to his initiative.

Mr. F. W. CHURCH seconded the vote, which was heartily passed.

An Extraordinary Meeting followed, at which resolutions were unanimously passed, changing the name of the Company to the Montevideo Gas & Dry Dock Company, Ltd., and altering the Articles of Association.

The CHAIRMAN explained that the intention was to bring the articles up to date. The remuneration of the Directors was increased from £1500 to £2000 a year, free of income-tax, so long as the Board did not exceed four in number. A further provision was made in the event of there being a fifth Director, the remuneration in that case being increased to £2500. The Directors had in view the probable retirement of Mr. Lane from Monte Video. He had served them, to the great benefit of the Company, for 47 years; and when he returned to this country they would like to have him on the Board.

On the proposition of Mr. RUSSELL, the Chairman and Directors were cordially thanked for their services.

CAPE TOWN AND DISTRICT GAS LIGHT AND COKE COMPANY.

A Record Make of Gas.

The Ordinary General Meeting of the Company was held last Wednesday, at Egypt House, Nos. 36 to 38, New Broad Street, E.C.—Mr. J. E. LILLEY in the chair.

The SECRETARY (Mr. R. W. Blackburn) read the notice convening the meeting; and the Directors' report and the statement of accounts for the year ended Dec. 31 were taken as read.

The CHAIRMAN, in formally moving the adoption of the report and accounts, said that the quantity of gas made during the past year was the largest in the history of the Company. They did not, however, get the full benefit of this manufacture in their receipts, because unfortunately the quantity of unaccounted-for gas was larger than was the case in the previous year. As a matter of fact, the leakage, he was sorry to say, was 4 p.ct. greater than in the year before. This increase was observed during the year, as periodical statistics reached the Board from the other side; and they directed the attention of the Manager to the matter. The most careful search had been made. The ground had been stabbed in all directions, and the plant had been thoroughly gone over; but no abnormal leakage had been found. They were therefore driven to the conclusion that the larger quantity of unaccounted-for gas had resulted from the imperfections of the meters.

METERS DIFFICULT TO OBTAIN.

As was stated in the report, they had been unable to get meters for a large part of the year; and there had been considerable restriction all through the war. They had repaired those in their possession to the best of their ability, and as far as they could get skilled men and the materials necessary; but some of the material—such as the various parts of the meters—they could not get at all. Even diaphragms they could not procure. They did their best to make some; but, as he stated a year ago, they had been very doubtful of the result. They found, however, that the diaphragms they made themselves acted fairly well, though they did not have a good choice of leather. The result had been very useful; but they did not pretend that the diaphragms were as good as those imported from this country. Altogether there had been very great difficulties in the meter department. A large number of meters had been brought in, and many of these worked slow, which, of course, was the natural result of their long usage; while some of them had stopped entirely. They did not want to lose customers, and in some cases, rather than run the risk of doing so, had agreed with customers upon whom they could rely to supply gas to them without measurement at all, on the basis of former consumption. The Directors thought it wise to do this, though one could not expect under these conditions very accurate returns. He was pleased to say that meters were now being supplied as fast as their people could fix them; and they would continue to send them out as quickly as required. The Board did not hesitate to spend money

* Reference is made to this letter on another page.

where they could do so usefully; and, as a matter of fact, they had spent a considerable sum more on meters and repairs to them than in previous years. They could have supplied more gas if they had had a larger number of meters. As was pointed out in the report, they had 204 fewer consumers than in the preceding year. This was entirely due to their inability to supply them with meters. On Dec. 31, they had 410 applicants waiting for a supply of gas. It was hoped now to be able to give them soon what they required, because the restrictions had been taken off the supply of meters.

PRICE OF GAS NOT INCREASED.

The additional £5000 received from sales of gas had not been earned by any increase in price, which had been kept at the same figure as before. It was entirely due to the larger sales. Their competitors who supplied electricity and oil had increased their prices. In residuals the Company had done fairly well, having made £1000 more. They would, however, have done still better, but for the inferior coal which they had been compelled to use. The railways were blocked with the carriage of war material; and it had been impossible to get coal from their ordinary sources. They had had to buy any they could get hold of; and some was very unsuitable for gas-making purposes. The result was a very poor production of coke and tar; but with regard to gas, the effect did not seem to be so bad as on the residuals. In addition to the already inferior quality of the coal, some of it was made still more inferior through a large pile getting heated from spontaneous combustion. Their Manager had very wisely got in a full stock; and unfortunately a big heap had become heated in this way. The coal was removed, and the heating stopped, as soon as possible; but the result had been bad from the point of view of coke production, very much more breeze being formed.

FACING INCREASED COSTS.

In the fittings department, the sales had resulted profitably. They could not get new fittings; and customers, if they were determined to have them, were very glad to have those in stock. As the shareholders were aware, the Company had always made a practice of writing these fittings in stock down to the market value of the time—some had even been written down to nothing—and, during the scarcity of the past year, it had been possible to get very good prices indeed for some of this old stock. With regard to the debit side, manufacture and distribution of gas had cost roughly £5000 more than in the previous year. About £4000 of this was due to the extra cost of coal and other materials, and upwards of £900 was for increased wages in the carbonizing department. A portion of these increased wages resulted from the necessity of using a greater proportion of old plant, with which more labour was required; but the greater part was occasioned by the rise in the scale of wages that had had to be paid. In the repair and maintenance department, they had spent about £460 more. They would have spent a larger amount, had they been able to get their meters in proper order; but as it was they had reserved an extra sum of money for this year. Returning to the question of wages, he might say that, taking the manufacturing and distribution departments and the maintenance of the plant together, wages had cost £2650 more than in the previous year. Materials were also much higher in price. Having thought it necessary to reserve, as he had said, a larger sum for renewals of plant, &c., the Directors had set aside £4000 as against £3000 last year. It was not a penny too much, because they had heavy expenses to face. They were put to very great disadvantage during part of the year—as, indeed, everybody was in South Africa—by the severe epidemic of influenza. For about two months in the autumn, their men suffered very badly; and on one occasion the Manager had only one man left in the manufacturing department. Working night and day with this man, he managed to keep the works going until some of the other men were able to get back and help. The same thing occurred in the business department. The local Secretary was also left with only one man to carry on. They themselves were not in the best condition to continue at work; but they most loyally stood to, and pulled things through. The Directors had, of course, expressed their appreciation of these good and loyal services in warm terms, and had made it clear that these expressions were sincere by giving financial recognition as well.

A LARGE OUTLAY ON PLANT FORESHADOWED.

Now with regard to the quantity of gas required. The demand was not a regular one; and on certain occasions it had been up to the full manufacturing capacity of the plant. The Directors saw that it was not safe for them to face another heavy season under these conditions; and they therefore made arrangements to reconstruct a further portion of the old plant, as it was impossible to get new plant yet. This had been done on lines which it was anticipated would result fairly satisfactorily. They could not obtain the materials from this country, and so had had to do what they had never done before—procure what he believed had not hitherto been produced in South Africa. That was to say, they had obtained there the castings for the reconstructed retorts. They had also managed to get the retorts themselves there, though it was impossible to say what their life would be. It was, however, stated that in appearance the retorts were quite good; and he did not doubt that they would last them for at any rate two or three years. They would have preferred to get the fire-resisting material and cast iron from this country; but it was not possible. With this reconstructed plant, the Directors felt that they would be safe for about two years to come; and by the end of that time, they hoped to be able to get new plant from this side which would serve them as well as the last they had. The vertical retorts continued to work excellently; and they only wished they could make all the gas by this means. The Board would in the meantime very carefully watch carbonizing progress in this and other countries, so as to decide which would be the best system to adopt. As to the use of blue water gas all over the country, during the shortage of coal it had been recommended that such gas should be made and mixed with coal gas. Their Company

USE Simmance's

DEAD BEAT INDICATORS

instead of WATER-TUBE GAUGES and

"READ THE PRESSURE BY THE POINTER."

No liquid to evaporate and no levels to adjust.

No glasses to break and nothing to clean.

Direct reading, Open scale, Any range (Pressure, Vacuum, or Combination).

Incorrodible, Accurate, for foul or purified gas.

MADE IN MANY RANGES WITH TABLETS LETTERED AS DESIRED.

ALEXANDER WRIGHT & CO., LTD., WESTMINSTER.

Agents: Australia—FYVIE & STEWART, 360, Collins St., Melbourne; Canada—W. P. ROPER, 502, Merchants' Bank Building, Montreal.

had been doing this for the last ten or twelve years; and they had found that it answered satisfactorily. It was now being adopted very largely indeed; and the Directors were glad that they should have been so early in the field with the use of it. They hoped, with better retorts, to be able to use still more of this cheap form of gas. At present they could not employ such a large proportion as they would like to do, because the calorific value was not so high as that of coal gas. Turning to the question of expenses in the future, it would be gathered from what he had said that a good deal of new plant would be required. New boilers had been ordered of a larger kind than the old ones; and new condensers were also in hand. New washers would be required; and for these they were on the point of getting tenders. Then they would be requiring a very large number of new meters. All this foreshadowed a great deal of expense during the coming year. As a matter of fact, he did not expect they would get through with it under £8000. Wages, of course, were still rising; and legislation had recently taken place respecting the hours of labour. They were not to be allowed to employ any man for more than 51 hours per week. This would affect the Company very considerably, because they had been operating their carbonizing department in two shifts of twelve hours each. In future they would have to work three shifts; and it might be taken for granted that the rate of pay per day would not be much less than in the past, although the hours would be so much shorter. This new arrangement was a pity, because there was no hardship in working in two shifts. However, there would be an increased expenditure in this respect to face. Their rateable assessment had been increased by £10,000, which meant that the rates would be more in the future, but not to the same extent as would be implied by a similar increase in this country. In Cape Town the rates were assessed on capital value, and not on the annual value; so that the amount in the pound would be perhaps 4½d. or 5d., instead of 8s. or more as in this country. To counteract this, rents receivable had increased again in the past year.

MEETING DEMANDS UPON THE COMPANY.

The shareholders would probably feel interested in knowing how the Board expected to meet these extra demands upon them. In the first place, they looked for a continuation of the increase in business which had been experienced in the portion of the year already passed. Then there was the £4000 set aside for renewals. It might be thought that £10,400 in cash was a large sum to show in the accounts; but at that time the income-tax had not been paid, and there was something over £7000 to pay for this, as well as the debenture interest. As to the allocation of the profit made during the year, it would be noticed that, including the balance brought forward from the previous accounts, there was a sum of £22,669 at the credit of profit and loss account—£21,110 having been made during the year, after payment of debenture interest. There had been transferred to reserve and contingency account £2500, and to reserve for plant, &c., renewals £4000. Then £4500 had been paid in the shape of arrears of dividend on the preference shares; and the Board were proposing to pay a further sum of £9000 on this account, leaving a balance of £2207 to carry forward, which was larger than in the previous year.

The VICE-CHAIRMAN (Mr. H. R. Savory) seconded the motion.

Mr. G. MOODY drew attention to the deduction for income-tax made when the dividend warrants were sent out to the preference shareholders last November. He said the profits they were considering the distribution of were made when the income-tax was, not 6s. but 5s. 9d. in the pound. Therefore the deduction should have been at the latter, and not the former, rate. He hoped the matter would be adjusted.

Mr. T. E. PADDON asked why they did not increase the price of gas in Cape Town, as had been done in this country.

Mr. E. NICHOLLS asked when the ordinary shareholders might expect to hear something about a dividend for them.

The CHAIRMAN promised that the point about income-tax should be carefully considered. He said the price of gas in Cape Town was already high—8s. 4d. per 1000 c.ft. for ordinary, and 10s. for automatic consumers. The Board felt that to increase the price beyond these figures would very much militate against the progress of the undertaking. If they had not had to pay off arrears on the preference shares, they could this time very well have distributed 9 p.ct. on the ordinary shares. He did not care to prophesy, but he thought there could be no doubt, if the business went on satisfactorily, that they would be able to pay a dividend of some sort on the ordinary shares the year after next.

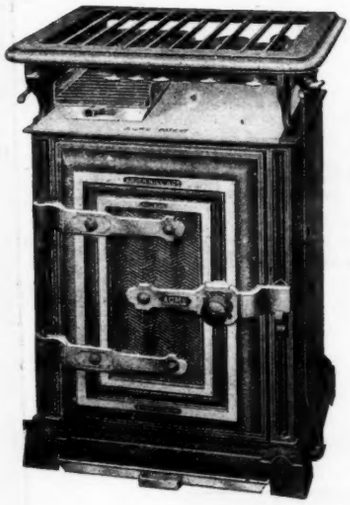
The resolution was then carried; the retiring Director (Mr. R. A. Fairclough) and the Auditors (Messrs. Kemp, Sons, Sendell, & Co.) were re-elected; and the Chairman and Directors were heartily thanked for their services.

NOTTINGHAM GAS UNDERTAKING.

A Profit of £95,029.

It is fortunate that in its present heavily-burdened condition, Nottingham is able to rely upon two highly remunerative municipal undertakings in relief of the rates. Reports presented at a meeting of the City Council yesterday show that, from profits upon gas and tramways, £60,000 is to be allocated this year; each undertaking contributing £30,000.

The report of the Gas Committee is again illustrative of sound administration, showing that the total income on the revenue account for the past year amounted to £468,529, and the expenditure to £373,499, leaving a balance of £95,029 to be carried to the profit and loss account, *plus* £30,447 brought forward from last year, and banker's interest, interest on war stocks, &c.—making a total of £133,234. After deducting the interest on capital, the contributions to the sinking



ARDEN HILL & Co's
"SUPER-ACME"
GAS COOKERS
- ARE IDEAL FOR DOMESTIC USE -

They are Porcelain-enamelled inside and out, and are maintained at quite a low cost. The oven is of large capacity, the gas taps are at the front, therefore easily accessible. There is perfect ventilation and uniform heat. The hot-plate is hinged, and when it is raised the burners are easily removed for cleaning.

Full particulars of Sizes and Prices on application to the Makers.

ARDEN HILL & CO.,
"Acme" Works - Birmingham.

funds, and placing £3500 to depreciation of stoves, there remains a balance of £70,228 at the disposal of the Council. The Committee recommended that out of this amount the sum of £30,000 be handed over to the Finance Committee in aid of the general district rate, £10,000 be placed to the renewals fund, and the balance (£30,228) carried forward.

The quantity of gas sold during the year was 2,059,370,900 c.ft., against 2,244,670,300 c.ft. the previous year, being a decrease of 185,299,400 c.ft., and a decrease of 191,931,800 c.ft. as compared with the year ended March 31, 1914. Hence the operation of war conditions and the Household Fuel and Lighting Order (1918) has resulted in a very substantial reduction in consumption. The amount of gas sold per ton of coal carbonized was 12,292 c.ft., as against 12,004 c.ft. last year. The gas sold for public lighting was 13,083,800 c.ft., as compared with 102,143,500 c.ft. for the year ended March 31, 1914.

Considerable difficulty was experienced in keeping up the gas supply during the winter months, in consequence of shortage of coal, gas oil, and labour; and a quantity of Durham gas coal was allocated to the department, in order to tide-over the difficulty. The Radford works have been in the possession of the Ministry of Munitions throughout the whole of the financial year, and are still under the Ministry's control; but it is anticipated that the works will be handed back to the Committee at an early date. Upwards of 1,000,000 gallons of excellent fuel oil for naval purposes were produced during the year at Radford. In accordance with instructions issued by the City Council an application has been lodged with the Board of Trade in respect of the substitution of a standard of calorific power in place of the present standard of illuminating power. The Committee in presenting the report desired to make it perfectly clear that the revenue account has not yet been called upon to bear a full year's charges in respect of the increased war wages and bonuses and the latest prices for coal and general materials.

The Engineer's Report.

The eighth annual report of the Engineer and General Manager (Mr. John Wilkinson) states that during the period under review, 132,008 tons of coal and 77,009 gallons of oil were utilized in manufacturing 1,812,670,000 c.ft. of coal gas and water gas. The report shows that in addition to the figures relating to gas produced at the respective works, 394,862,000 c.ft. were purchased from the Ministry of Munitions—such gas being available for sale as the result of carbonizing cannel coal for the production of fuel oil at the Radford works. The gas available for consumers was therefore 2,207,532,000 c.ft. In sales of gas, there was a decrease of 185,299,400 c.ft., or 8·25 p.ct., when compared with the previous year.

The gas unaccounted for during the year was 148,161,100 c.ft., or 6·71 p.ct., as compared with 65,857,700 c.ft., or 2·85 p.ct. Last year's figure of 2·85 p.ct. was abnormally low; but, Mr. Wilkinson adds, this year's figure of 6·71 p.ct. is unquestionably too high, having regard to the experience of past years. It would therefore appear that a considerable quantity of unregistered gas has passed through dry meters which are known to be fitted with defective diaphragms. Considerable trouble has been experienced in consequence of a very large number of dry meters passing gas without registering; and efforts to deal with the position have been seriously retarded in consequence of inability to secure the speedy repair of defective meters and to obtain delivery of new meters. Nottingham's experience in respect of faulty diaphragms in dry meters is not unique.

The sale of gas per ton of coal carbonized was 12,292 c.ft., as compared with 12,004 c.ft. for the previous year. Ten years ago, the sale of gas per ton of coal carbonized was 10,564 c.ft.

IMPROVED RESULTS AT BLACKBURN.

One of the Best Years on Record.

In closing his report to the Gas Committee on the working of the Blackburn Corporation gas undertaking for the year ended March 25 last, Mr. John W. M'Lusky (the Engineer and General Manager) says: On the year's working there is a gross profit of £47,653; and after deducting annual charges, there remains £12,710 net profit to set against last year's loss. Despite an advance in price of coal per ton of 3s. 8d. average over the year, which in our estimate was set down at an advance of £8000, the carbonizing bill is less than last year by £1911; while the production of gas has been increased by 6 million c.ft. Revenue from sale of gas has been increased by £32,729, which includes an increased sale of over 4 million c.ft. The expenditure on the year's working has naturally been very heavy, as both works have been in operation to ensure a steady gas in volume and composition. That this has been accomplished, is proved beyond all doubt by the enormous decrease in complaints. In my annual report last year, I assured the Committee that no effort would be spared to make the very best of a difficult task. The plant at both works was inspected by the Committee last summer, and the difficulties of successful gas production very clearly demonstrated. With this visit in their minds, the Committee cannot be other than highly satisfied with the results as published. With the following points under consideration: (1) Rapidly increasing standard rates of wages to all employees; (2) large increases in cost of all classes of stores and materials; and (3) abnormal maintenance of inefficient plant—the year's working results may be safely reckoned as one of the best on record.

The quantity of gas sent out in the past twelve months was 734,080,000 c.ft., as compared with 728,225,000 c.ft. in the previous year; and the unaccounted-for gas equalled 7·08 p.ct. of the production, as compared with 7·15 p.ct. a year ago. A very extensive scheme of renewals of mains and services is in progress which, in addition to improving the supply in many districts, will at the same time tend to reduce leakage. The total wages amounted to 14·99d. per 1000 c.ft. of gas sold, compared with 7·04d. in 1914-15, and 10·42d. a year ago; the average weekly rate being £1 13s. 11d. in 1914-15, £2 7s. 9d. in 1917-18, and £3 4s. 11d. in 1918-19.

"BEARSCOT" SPECIALITIES

R. & J. DEMPSTER, LTD.,

MANCHESTER.

Temporary London Office

BLENHEIM MANSIONS, BROADWAY, WESTMINSTER, S.W.1.

London Office Telephone No. Vic. 7426.

FIT YOUR NEW PLANT WITH

AS APPLIED TO

GAS HOLDERS · PURIFIERS · CONDENSERS · WECKS VALVES · WASHER SCRUBBERS · &c. &c.

The net proceeds from residual products on cost of coal equalled 71·39 p.ct. in the past year, against 62·2 p.ct. in the preceding twelve months. On this point, Mr. M'Lusky remarks: The improved methods of working have not only effected considerable saving in coal, but have also improved the quantity and quality of the residual products. The analysis of income from sale of products reveals the interesting fact that, while the average price of coal was advanced from 22s. 0·88d. to 25s. 8·42d. per ton, the net cost of coal to the department was reduced from 10s. 0·67d. to 7s. 4·21d. per ton. Three factors are credited with this remarkable statement: (1) Improved methods in works; (2) commercial enterprise; and (3) rising market values.

Actually the net profit for the past year was £21,459; but this figure has been reduced to the one named above by placing to expenditure on revenue account the sum of £748 required in excess of borrowing powers to complete the tar distillation plant, placing to reserve £8000 to be used during the current year in the renewal of plant, mains, services, and appliances generally.

With so excellent a set of accounts before him, Mr. M'Lusky is recommending substantial reductions in the prices charged for gas.

NEW VERTICALS FOR LEICESTER.

The Leicester Town Council decided at its meeting last Tuesday, to make a further large expenditure on new verticals. The Gas Committee recommended that the outlay should be met by charging £92,247 to capital account—to be repaid within a period of ten years—and that £16,500 should be paid out of revenue spread over a period of three years. They also recommended that a sum equal to 1½ p.ct. on the total borrowed capital should be credited yearly in due proportion to the reserve and renewals funds, until these funds were complete. They further proposed that powers should be sought at the earliest opportunity to increase the renewals fund from £20,000 to £150,000.

Mr. G. E. Hilton moved the adoption of the report and the acceptance of a tender for the installation of the new retorts at the Aylestone and Belgrave Gate works. In regard to the financial recommendations of the Committee, he said it might be thought that they should receive something from the reserve fund, but this would be illegal—anyway it would be unwise to deplete the reserve fund. Therefore, except for £16,000 owing upon the old plant, which was to come out of revenue, the Committee recommended that the remainder of the money should be borrowed.

Alderman Sir J. North considered £20,000 to be allotted yearly to the reserve was ample; but he questioned the justice of the £16,000 being paid out of revenue. He was fully conscious of the feeling which prevailed, that municipal undertakings should be run for the benefit of the residents. But while sympathizing with the idea of municipal trading, he thought it would be unwise to remove altogether the incentive of a reasonable profit. The ratepayers were responsible for the municipal undertakings and were entitled to the benefit of a fair profit. Once the principle was established that they were not working for profit, they would get lax management.

Mr. Murby approved of the installation of the new retorts, long overdue. The work would be of benefit to the public; but consumers would not be content for all time to be exploited at the rate of 3s. 4d. per 1000 c.ft. of gas sold for the sort of gas they had been getting lately. He should like to see some of the reserve fund spent upon the work, instead of borrowing all the money for it. Following upon this installation they would ask that the price of gas should be considered and that the men displaced should be found other work under the Corporation.

Replying upon the discussion, Mr. Hilton said with regard to the £16,000 the Local Government Board would make it a condition that this debt on the old plant should be paid off.

The report and recommendations were thereupon adopted.

ROTHERHAM GAS-WORKS ACCOUNTS.

Mr. J. S. Naylor, the Engineer and General Manager of the Rotherham Corporation Gas Department, in his report to the Gas Committee for the year ended March 31, says the quantity of coal carbonized during the year was 24,680 tons, at a cost of £28,870, or 23s. 4·75d. per ton, as against 26,316 tons last year, costing £24,627, or 18s. 8·60d. per ton, being a decrease of 1636 tons, and an increase of £4243 respectively. The gas made was 324,659,000 c.ft., as against 355,410,000 c.ft., being a decrease of 30,751,000 c.ft. This decrease is due to the department having bought nearly 25,500,000 c.ft. of coke-oven gas from Messrs. J. Brown & Co., Ltd., of Canklow. The gas made per ton of coal carbonized was 13,154 c.ft., as against 13,505 c.ft., being a decrease of 351 c.ft. per ton. The quantity of gas sold was 306,703,000 c.ft., as against 309,396,000 c.ft., being a decrease of 2,693,000 c.ft. The unaccounted-for gas was 38,703,000 c.ft., or 11·05 p.ct. of the make, as against 42,616,000 c.ft. last year, or 11·03 p.ct., a decrease of 0·88 p.ct.

The cost of public lighting in the borough, including wages and maintenance of lamps, amounted to £2585, as against £1354 last year, being an increase of £1231. The cost of gas for public lighting amounted to £387, as against £307, being an increase of £80. The amount of gross profit made is £10,809, as against £14,061, being a decrease of £3252. The net profit, after allowing for interest, redemption instalments, and contributions to sinking funds, amounts to £871, as against £4189, a decrease of £3318. If the gas for public lighting (£387) is again given by the department, as in former years, there remains a surplus of £483—a decrease of £3399.

Gas Plant and all constructional Steel and Iron Work.

Specialists in Slot Meters, Ordinary Meters, Wet & Dry.

WILLEY & CO., LTD., ENGINEERS,

EXETER, LONDON, MANCHESTER, LEICESTER.

The Pioneers of Slot Installations.

Gas Fires.

Gas Fittings.

Gas Cookers.

PICKERING'S VALVE. LIVESEY WASHERS.

Telegrams:
"WILLEY, EXETER."
"GASVILLADO, KINLAND, LONDON."
"METERS, LEICESTER."
"WILMETER, MANCHESTER."
Telephone Nos.:
132 EXETER
224 DALSTON, LONDON.
4777 LEICESTER.
7419 CITY, MANCHESTER.

NOTE ADDRESSES.

Head Offices: EXETER.
London Works and Offices:
89-95, HERTFORD ROAD, KINGSLAND, N.
5, Oxendon Street, LEICESTER.
John Street, Booth Street West, MANCHESTER, S.W.

ROAD-TARRING AND FISHERIES.

There has been manifest for some time past a growing apprehension among fishery owners with regard to the effect on fisheries of the tarring of road-surfaces, to which cause the deterioration which has taken place in the fisheries of certain rivers has been commonly assigned.

The matter has been considered by the Board of Agriculture and the Road Board, who appointed a Joint Sub-Committee to arrange for experiments to be carried out in order to ascertain whether there is any foundation for the allegation that tar-treated roads are a source of danger to fisheries; if so, to what extent; and what measures can be taken to minimize or obviate the possible danger. The Sub-Committee consists of Dr. Jee, the Chemical Adviser to the Board of Agriculture; Dr. Hammond Smith, the Scientific Adviser to the Salmon and Trout Association; Mr. W. J. A. Butterfield, F.I.C., Consulting Analytical Chemist to the Road Board; and Mr. W. J. Taylor, County Surveyor of Hampshire.

Until these experiments can be carried out, highway authorities are being urged to exercise the greatest care in the execution of all surface tarring works. Refined tar, and of a grade not lower than the Road Board specification, should only be used; and, where possible, provision should be made by way of catch-pits, gravel beds, draining on to grass margins, or in any other manner available, to prevent surface water from tar-treated roads running directly into streams.

DUBLIN'S HIGH ELECTRICITY CHARGES.

A good deal of feeling has been aroused in Dublin by a proposal to prepare a revised scale of charges for electricity, with the object, as alleged, of making permanent—or at least further extending—increases imposed last year, owing, as then stated, to the coal scarcity.

The "Irish Independent," commenting on the position, says the 10 p.ct. increase imposed as a temporary measure remains in force, and, with regard to the recent increases, the coal scarcity has diminished. These increases were put on, not for revenue, but to increase consumption. "Now the excuse is that consumption is so reduced that the price must be kept up to maintain the revenue." "The fact is," adds the "Independent," "that the Electricity Supply Committee have so muddled the undertaking that they can only avoid a demand on the ratepayers by fleecing the consumers. When the Corporation began to trade in electricity, the ratepayers were told of the immense relief they would receive from the profits of the concern. Instead of relief, the undertaking still owes the ratepayers about £40,000, which probably never will be repaid. Now it is the turn of the consumers. They are compelled to pay for the mismanagement and incompetence of the Electricity Supply Committee."

CURRENT SALES OF GAS PRODUCTS.

The London Market for Tar, Tar Products, and Sulphate.

London, *June* 2.

In spite of the lateness of the season, it is reported that a certain amount of pitch is still being shipped. The price continues unchanged at the figure last recorded. There is a fair demand for tar for road work. In other products, current values are as follows: Creosote, 5½d. to 6d. per gallon. Pure toluol, 2s. 9d. to 3s. per gallon Solvent naphtha, about 2s. 4½d. per gallon. Anthracene, 48/50 p.ct., 7d. to 8d. per unit, casks free.

In sulphate of ammonia, the price for the period June/September has now been fixed at £17 per ton to farmers, or £16 10s. per ton to dealers, delivered free to consumers' station in minimum 2-ton lots—basis, 24½ p.ct. ammonia—an increase or deduction of 4s. per ton to be made for each variation of ¼ p.ct. in the test.

Tar Products in the Provinces.

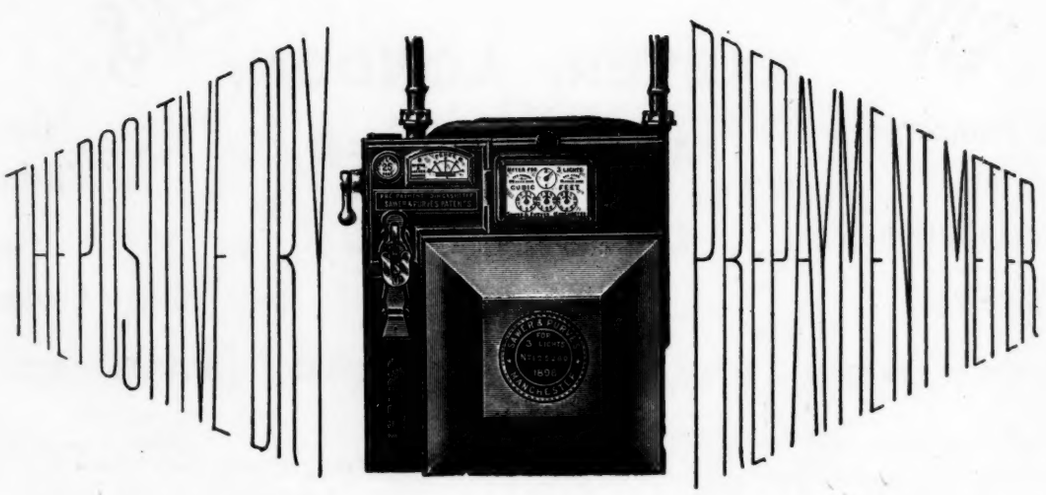
June 2.

The average values for gas-works products during the week were: Gas-works coal tar, 35s. 6d. to 40s. 6d. Pitch, East Coast, 56s. to 58s. 6d. per ton f.a.s.; West Coast—Manchester 45s. to 46s.; Liverpool, 46s. to 46s. 6d., Clyde, 52s. 6d. to 55s. nominal. Benzol 90 p.ct., North, 1s. 9d. to 1s. 11d.; crude, 65 p.ct., at 120° C., 1s. 1d. to 1s. 2d. naked at makers' works; 50-90 p.ct. naked, North, 1s. 9d. to 1s. 10d. Toluol, naked, North, 2s. to 2s. 1d. nominal. Coal tar crude naphtha in bulk North, 7¾d. to 8¼d. Solvent naphtha, naked, North, 1s. 10d. to 2s. 1d. Heavy naphtha, North, 2s. 5d. to 2s. 7d. Creosote, in bulk, North, liquid, 5d. to 5¼d.; salty, 4½d. to 5d. Heavy oils, in bulk, North, 6d. to 6½d. Carbolic acid, 60 p.ct., unsaleable. Naphthalene, £16 to £19; salts, £5 to £6, bags included. Anthracene "A" quality, 7d. to 7¼d. per minimum 40 p.ct.; "B" quality, 2d. nominal.

Manchester District Tar Prices.

The average price realized for tar in the Manchester district, based on the value of the products, for the month of April was £2 6s. 8d. per ton.

SAWER & PURVES,



MANCHESTER & NOTTINGHAM.

FROM A MARKET CORRESPONDENT.

Tar Products.

A steady business in tar products is being maintained. The strength of the pitch situation seems to be increasing. London inquiries for autumn and later shipment are very good; and although spot prices are not altered, a premium could probably be obtained for later positions. Continental buyers may wait before making any large fixtures. Shipments will have to be suspended for a few months; but sellers are very confident, and believe that higher prices must come. Welsh buyers are still in the market, and their requirements will not be satisfied just yet. Stocks of pitch generally are at present being reduced; but during the hot weather some accumulation may be looked for. Holders believe, however, that the large road-making demand, which has yet to be satisfied, will more than compensate for diminished shipments. Provincial quotations are well held, and transactions are reported from Manchester at 50s. per ton f.o.r., and on the East Coast at 56s. per ton f.o.b. Creosote remains particularly firm; and there is a good demand for fuel purposes. Prepared tar are a good market; and there is prospect of a further improvement in prices. Solvent naphtha continues very flat; there being practically no demand at present. Heavy and crude are without change. Naphthalene is quiet; business being very small, and prices are again on the down-grade. Cresylic acid is steady; but the position in carbolic acid does not seem to get any better. Information reaches me that American houses are offering crystals at practically the pre-war price—about 3½d. per lb.; but the nominal quotation here is 4d. per lb. Benzol is a steady market, although there is a tendency to shade prices a trifle as a consequence of the lower rates for petrol. It is, of course, quite possible that present prices may not be maintained, because, with the improvement in shipping facilities, petrol prices will come down further. But if benzol keeps at the same price as petrol, the trade should be satisfied. The present demand is an expanding one, which is quite certain to develop further—particularly if the public are brought to realize its superior thermal value. There is a very strong Irish demand at present, and most makers can readily dispose of their output locally. Pure qualities are fetching up to 3s.; toluol being quoted at the same figure. Other products are without change.

The range of home quotations is as follows:

Benzol: 90% London 2s. to 2s. 2d., North 1s. 11d. to 2s.; 50-90% 1s. 9d. to 2s. London, 1s. 9½d. North; crude 60-65% 1s. 3½d. to 1s. 5½d.; pure, 3s. per gallon naked.

Carbolic Acid: Crude 60's unsaleable; crystals 40%, 4d. per lb. asked.

Crude Tar: London, 44s. to 46s.; Midlands, 40s. to 42s.; North 40s. per ton *ex* works.

Pitch: London, 67s. 6d. to 70s. per ton; East Coast, 54s. to 56s. per ton; West Coast, 46s. to 48s., with Manchester 47s. per ton and Glasgow 47s. 6d. per ton; South Wales, 56s. to 58s. per ton.

Solvent Naphtha: London, 2s. to 2s. 1d. Provinces average 2s. per gallon.

Crude Naphtha: Naked, 10d. per gallon.

Heavy Naphtha: 2s. 3d. per gallon.

Naphthalene: Refined, £15 to £17 10s. per ton nominal; crude, £4 to £9, according to quality.

Toluol: Naked, 2s. 9d. per gallon nominal. North 2s. 7d.

Creosote: London, 7¾d.; North, 6¾d. to 7d.; heavy oil, 7¼d. per gallon in bulk.

Anthracene: 40-45%, 6d. to 8d. per unit per cwt.

Grease Oils: 18° Tw. (naked), £6 10s. per ton f.o.r. makers' works.

Aniline Oil: 1s. 2d. per lb.

Cresylic Acid: 95%, 2s. 9d. to 2s. 10d.; 97-99%, 2s. 11d. to 3s. 3d. *ex* works London, f.o.b. other ports.

Sulphate of Ammonia.

The market is at present a waiting one. Control is now removed; and until we get further into the month, there cannot be much to record in connection with it. Judging by recent sales, foreign buyers are still willing to pay about £30 per ton for spot. For later positions, however, they are waiting to see what offers will be made by other quarters with an exportable surplus. Merchants, too, are cautious in dealing with any foreign inquiry; so that a proper price basis may be established which will not interfere with the prospective position. I hear that some good-sized shipments to Spain from America and elsewhere have just been made, and it would be interesting to know whether the Sales Association intend approaching the American organization with a view to establishing a working arrangement, which, it is generally believed, would have mutually satisfactory results. Very mixed views are held in the trade regarding the German position; but this will probably become clearer when the peace preliminaries are settled.

Wages at Halifax.—The Halifax War Wages Committee, last Friday week, again considered an application by the Workers' Union for a 5s. wages increase to all their members employed by the Corporation; but the Committee re-affirmed a previous decision recommending the Council to refuse the application. At the same time, they expressed willingness for the Union to submit the matter to the Committee on Production for arbitration. The workers affected are already receiving 30s. per week above pre-war rates.

Gas and Electricity Extensions at Manchester.—The Manchester City Council, at their meeting to-morrow (Wednesday), will be asked to sanction the expenditure of over £2,000,000 on various works; nearly the whole of this amount being in respect of the gas and electricity undertakings. The Gas Committee will apply for permission to borrow the sum of £921,000 for the new works which were planned some time ago. It is intended to enlarge both the Bradford Road and the Droylsden gas-works, as well as to carry out other important extensions. The schemes are so well advanced that some of the work can be taken in hand at an early date. The Electricity Committee's financial requirements amount to £1,042,000 for the erection and equipment of a new generating station at Barton, work on which, it is expected, will be commenced next autumn.

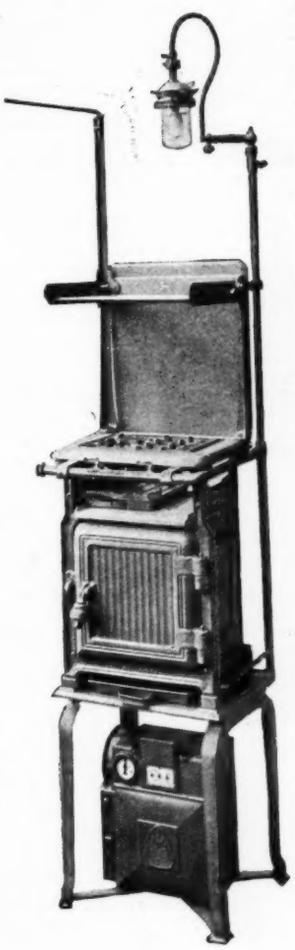
A Complete

Slot Installation

THE MAIN COMBINATION

Comprising:

Prepayment Meter.
Cooker on Stand.
Plate Rack and Enamelled Backplate.
Towel Rail.
Inverted Incandescent Burner, and Connection for Extensions.



Specially designed for Workmen's Dwellings, Flats, Bungalows, and Houses for more than one tenant.

COMPACT AND COMPREHENSIVE.

Economises Space, Piping, and Labour in Fitting.

R. & A. MAIN, LTD.

WORKS:

Gothic Works, Edmonton, N. 18
Gothic Ironworks, Falkirk
AND
Gothic Works, Birmingham

Showrooms & Branches:

25, PRINCES STREET, OXFORD CIRCUS, W. 1; 82, Gordon Street, GLASGOW; 18, Severn Street, Deansgate, MANCHESTER; 97, Millfield, BELFAST; and 333, Queen Street, MELBOURNE.

Maximum By-Products, Ltd.—This is the title of a private company formed with a capital of £12,000 in £1 shares, to acquire from W. Antrobus, of Eccles, the benefit of certain inventions relating to improvements in the treatment of fuel for obtaining bye-products therefrom and to improvements in furnaces for the production of gas and bye-products from fuel.

British Dye-Stuffs Corporation, Ltd.—This concern has been registered with a capital of £6,000,000 in £1 shares, to take over the businesses of British Dyes, Ltd., and Levenstein, Ltd., to carry into effect agreements between these Companies and the President of the Board of Trade (on behalf of the Government), and to carry on the business of manufacturers of and dealers in dyes, dyestuffs, chemicals, drugs, paints, varnishes, colours, &c. One of the Articles of Association provides that the Company "shall supply products at reasonable prices." The first Directors are Mr. H. Levenstein, Sir Harry D. M'Gowan, Mr. G. P. Norton, and Mr. J. Turner, and two Government Directors to be appointed by the Board of Trade.

Salford Gas and the Rates.—At the last meeting of the Salford Borough Council, the Finance Committee's estimates were considered and approved. Last year's estimates were overspent by £35,432; the sum of £5875 in respect of the Lighting and Cleansing Department being one of the chief adverse balances. Of the trading committees, the gas and electricity departments had each contributed £10,000 in relief of rates; and similar amounts were estimated for this year.

Dublin Public Lighting Estimates.—A report of the Dublin Corporation Lighting Committee states that the public lighting expenditure has increased from £34,845 last year to an estimate of £42,790 for the current year; this being due to increased wages by reason of the Committee on Production awards, and increased cost of gas and electricity. Over these causes the Committee has no control. Exception is taken to statements made at a Council meeting on the rearrangement of the public lighting staff at Tara Street station. The Committee point out that they are working with a reduced staff, and that they have in no way increased the ordinary expenditure.

STOCK MARKET REPORT.

BUSINESS on the Stock Exchange was at very moderate pressure last week, and, barring a slight rally on Thursday, which was lost next day, the general tendency was dull. The delay in cutting short the transparent manœuvrings of German delegates at Versailles, labour unrest, and the impending new Loan were dominant factors which damped enterprise.

In the gilt-edged market, Home Government issues moved irregularly, but closed without much change. The 5 p.ct. Loan marked 94$\frac{1}{16}$; but Consols were not so good. Home Rails, after a poor start, improved and closed firm. Canadians were depressed by the strikes, and Argentines were disappointed upon recent rumours proving to be unwarranted.

Business in the Gas Market was much on a par with the record of the previous week—that is to say, the aggregate of transactions was quite up to a fair average, considering that Whitsuntide is so near at hand. It was not quite so disproportionately monopolized by two undertakings as in the week before, though they certainly attracted most attention. Imperial Continental had a fine progress, though a bit jumpy at times. From 135 on Tuesday, it touched 137$\frac{1}{4}$ on Wednesday, 140 on Thursday, and 145 on Friday; the quotation closing 7 up. Primitivas were less in the lime-light, but were fairly busy daily. The Metropolitan companies showed hardly any change. Alliance and Dublin had a smart advance of 6$\frac{1}{4}$. Activity in European was renewed, and the quotation rose $\frac{1}{2}$.

Bargains done for cash during the week were as follows: On Monday, Bombay 6, Continental Union 48$\frac{1}{4}$, ditto preference 70$\frac{1}{4}$, European 12$\frac{1}{4}$, 12$\frac{5}{16}$, 12$\frac{3}{8}$, 12$\frac{7}{16}$, 12$\frac{1}{2}$, Gas Light ordinary 61$\frac{1}{4}$, 61$\frac{1}{2}$, 61$\frac{5}{8}$, 61$\frac{3}{4}$, ditto maximum 55$\frac{1}{2}$, 56, Imperial Continental 135$\frac{1}{2}$, 136$\frac{1}{2}$, Monte Video 14$\frac{1}{4}$, 14$\frac{5}{16}$, Primitiva 36s., 36s. 3d., 37s., 37s. 6d., ditto preference 68s. 9d., 69s., Sheffield "A" 81$\frac{1}{4}$, ditto "C" 71$\frac{1}{4}$, South Metropolitan 61$\frac{1}{4}$, 61$\frac{1}{2}$, 62, South Suburban 78, Southend 10 p.ct. debenture 59, 59$\frac{1}{2}$. On Tuesday, Alliance and Dublin debenture 63$\frac{1}{2}$, European 12$\frac{3}{4}$, Gas Light ordinary 61, 61$\frac{1}{4}$, 61$\frac{3}{8}$, ditto maximum 55$\frac{1}{2}$, ditto preference 71$\frac{1}{4}$, ditto debenture 57$\frac{1}{4}$, 57$\frac{3}{8}$, Imperial Continental 135, 135$\frac{1}{4}$, 135$\frac{3}{8}$, Monte Video 14$\frac{1}{4}$, Primitiva 37s. 6d., 38s., 38s. 6d., ditto preference 66s. 10$\frac{1}{2}$d., 67s. 6d., San Paulo preference 8, ditto debenture 41$\frac{1}{2}$. On Wednesday, European 12$\frac{3}{4}$, Gas Light ordinary 61, 61$\frac{1}{4}$, ditto debenture 57, Imperial Continental 136, 136$\frac{1}{4}$, 136$\frac{3}{4}$, 137, 137$\frac{1}{2}$, Metropolitan of Melbourne 96, Monte Video 14, Primitiva 39s. 6d., ditto preference 67s. 6d., South Metropolitan 61$\frac{1}{2}$, 62$\frac{1}{4}$, Tottenham debenture 65$\frac{1}{2}$, Harwich 7 p.ct. ordinary 43s., 44s. On Thursday, Bombay 6, Gas Light ordinary 61, 61$\frac{1}{4}$, ditto debenture 57$\frac{1}{2}$, Imperial Continental 136$\frac{1}{2}$, 136$\frac{3}{4}$, 137$\frac{1}{2}$, 137$\frac{3}{4}$, 138$\frac{1}{4}$, 138$\frac{3}{8}$, 139, 140, Primitiva 37s. 6d., 39s., 39s. 6d., ditto preference 66s. 3d., 67s. 6d., South Metropolitan 61$\frac{1}{4}$, Tottenham debenture 66, Swindon "A" 65$\frac{3}{4}$, 66, 66$\frac{1}{4}$. On Friday, Gas Light ordinary, 61, 61$\frac{1}{4}$, 61$\frac{3}{8}$, 61$\frac{1}{2}$, 61$\frac{3}{4}$, ditto preference 71, 71$\frac{1}{2}$, ditto debenture 58, Imperial Continental 139, 139$\frac{1}{2}$, 139$\frac{3}{4}$, 140, 140$\frac{1}{2}$, 141, 142, 143, 143$\frac{1}{2}$, 144, 145, Primitiva 38s. 9d., 39s. 6d., 40s., ditto preference 66s. 9d., 66s. 10$\frac{1}{2}$d., 67s. 6d., South Metropolitan 61, 61$\frac{3}{4}$, 62$\frac{1}{4}$, Hong Kong and China 5 p.ct. debenture 77, 77$\frac{1}{2}$.

The Money Market was very firm, culminating in a sharp demand. The Bank rate is 5 p.ct., as fixed on April 5, 1917.

ANTE-WAR PRICES AND DIVIDENDS, LATEST DIVIDENDS, AND LAST WEEK'S BARGAINS.

Issue. £	Share.	When ex-Dividend.	Ante-War Dividend & Bonus p.c.	Last Dividend.	NAME.	Closing Prices. July 30, 1914.	Present Prices.	Lowest and Highest Prices of Bargains.
182,049	Stk.	Mar. 10	4	4%	Aldershot 4 p.c. Pref.	..	62—67	..
1,551,868	"	April 8	2½	2½%	Alliance & Dublin Ord.	59—64	56 - 60	..
274,000	"	July 10	4	4%	Do. 4 p.c. Deb.	76—79	61—63	63½
280,000	5	April 29	7½	8%	Bombay, Ltd.	5½—6½	5½—6½*	6
50,000	10	Feb. 26	16	12%	Bournemouth Gas and Water — 10 p.c.	29—30	20—23	..
882,110	10	"	7	7%	Bournemouth Gas and Water — B 7 p.c.	15—15½	10½—11½	..
115,000	10	"	6	6%	Bournemouth Gas and Water — Pref. 6 p.c.	13½—14	9½—10	..
159,740	—	"	—	4%	Bournemouth Gas and Water — 4 p.c. Deb.	..	66—68	..
992,045	Stk.	Feb. 26	14	37/-	Brentford A Consolid.	261—266	74—77	..
784,930	"	"	11	31/8	Do. B New	204—209	68—71	..
55,000	"	"	5	5%	Do. 5 p.c. Pref.	109—111	78—83	..
221,400	"	June 11	4	4%	Do. 4 p.c. Deb.	91—98	65—67	..
317,380	"	Feb. 26	11	7½%	Brighton & Hove Orig.	208—213	137—142	..
344,300	"	"	8	6½%	Do. A Ord. Stk.	154—159	94—99	..
988,500	Stk.	—	5	5%	Bristol 5 p.c. max.	..	..	..
680,000	20	Mar. 26	12½	10%	British	44—45	30½—31½	..
120,000	Stk.	June 26	4	4%	Do. 4 p.c. Deb. Stk.	88—90	64—66	..
245,771	"	"	4	4%	Buenos Aires 4 p.c. Deb.	85—87	50—53	..
100,000	10	—	—	—	CapeTown & Dis., Ltd.	1½—2½	4½—5½	..
100,000	10	—	—	4½%	Do. 4½ p.c. Pref.	4—6	7½—8½	..
100,000	Stk.	June 26	4½	4½%	Do. 4½ p.c. Deb. Stk.	70—75	62—67	..
157,150	"	Feb. 26	5	5%	Chester 5 p.c. Ord.	108—110	..	..
1,518,280	"	Feb. 12	5/9/4	80/-	Commercial 4 p.c. Stk.	106—108	62—65	..
560,000	"	"	5½	26/8	Do. 3½ p.c. do.	103—105	58—61	..
475,000	"	June 11	8	8%	Do. 3 p.c. Deb. Stk.	69½—71½	51—53	..
800,000	"	"	4	—	Continental Union Ltd.	76—79	48—53	48½
200,000	"	"	7	—	Do. 7 p.c. Pref.	115—118	70—75	70½
51,600	Stk.	Aug. 29	14½	12½%	Croydon A 10 p.c.	..	155—165	..
278,400	—	"	11½	9½%	Croydon B and C 7 p.c.	..	130—135	..
492,270	Stk.	—	6	6½%	Derby Con. Stk.	123—125	..	..
55,000	"	—	4	4%	Do. Deb. Stk.	102—104	..	..
1,002,180	10	July 29	10	5/0	European, Ltd.	17½—18	13—14	12½—13½
16,298,975	Stk.	Feb. 10	4/17/4	30/-	Gas Light and Coke — 4 p.c. Ord.	98—102	61—63	61—61½
2,600,000	"	"	3½	26/8	Gas Light and Coke — 3½ p.c. max.	76—79	55—57	55½—56
4,089,285	"	"	4	4%	Gas Light and Coke — 4 p.c. Con. Pref.	96—99	70—72	71—71½
4,674,850	"	June 11	8	8%	Gas Light and Coke — 3 p.c. Con. Deb.	72½—74½	56—58	57—58
180,000	"	"	10	10%	Gas Light and Coke — 10 p.c. Bonds	..	..	..
82,500	"	Mar. 12	5	4½%	Hastings & St. L. 5 p.c.	..	59—64	..
268,740	"	—	3½	2½%	Do. 3½ p.c	37—39	44—49	..
70,000	10	April 29	11	7%	Hongkong & China, Ltd.	16½—16½	7—8	..
86,600	Stk.	Sept. 12	9	8½%	Hornsey 7 p.c.	..	115—120	..
181,900	"	Mar. 12	7½	5½%	Ilford A and C.	151—154	90—95	..
65,780	"	"	6½	4½%	Do. B	115—118	69—74	..
66,500	"	June 26	4	4%	Do. 4 p.c. Deb.	92—94	62—65	..
4,940,000	"	May 14	9	4½%	Imperial Continental	150—160	140—145	135—145
1,325,000	"	Feb. 12	8½	8½%	Do. 8½ p.c. Deb. Red.	84—86	73—75	..
295,942	"	Mar. 12	6½	6½%	Lea Bridge Ord. 5 p.c.	119—121	90—95	..
2,498,905	"	Feb. 26	10	42/6	Liverpool 8 p.c. Ord. A / B	211—218 / 146—148	..	..
306,088	"	June 26	4	4%	Do 4 p.c. Pr. Deb. Stk.	..	..	..
165,736	"	Feb. 17	7/5/6	32½%	Maidstone 5 p.c.	..	58—63	..
75,000	5	June 11	6	3 %	Malta & Mediterranean Met. of Melbourne — 4½ p.c. Deb.	4½—4¾	3½—3¾	..
250,000	100	April 1	4½	4½%		99—101	90—97	96
541,920	20	May 28	4	5%	Monte Video, Ltd.	11½—12	12½—13½*	14—14$\frac{5}{16}$
1,876,892	Stk.	July 29	4½	8½%	Newcastle&Gateh'd Con.	98½—99½	67—69	..
529,705	"	June 26	8½	8½%	Do. 8½ p.c. Deb.	82—88	57—59	..
55,940	10	Feb. 26	7/14/0	7/0	North Middlesex 7 p.c.	14—15	9½—9¾	..
200,000	Stk.	May 14	8	8%	Oriental, Ltd.	117—122	101—104	..
60,000	5	Mar. 26	10	1/-	Ottoman, Ltd.	7½—7¾	4¾—5½	..
60,000	50	Feb. 26	13	7½%	Portsea, Island B	128—131	76—81	..
100,000	50	"	12	6½%	Do. C	118—121	58—63	..
249,980	5	April 29	8	—	Primitiva Ord.	5½—6	1½—2	36/—40/-
499,950	5	June 26	5	—	Do. 5 p.c. Pref.	4¾—5	3½—3¾	66/3—69/-
521,600	100	June 2	4	4%	Do. 4 p.c. Deb.	97—98	74—76	..
600,000	Stk.	July 31	4	4%	Do. " " 1911	..	50—53	..
346,198	"	June 26	4	4%	River Plate 4 p.c. Deb.	85—87	48—52	..
150,000	10	May 14	6	6/	San Paulo — 6 p.c. Pref.	10½—11	7½—8	8
125,000	50	July 1	5	5%	San Paulo — 5 p.c. Deb.	4¾—4¾	41—43	41¼
135,000	Stk.	Mar. 12	10	5%	Sheffield A	228—234	80—84	81½
209,984	"	"	10	5%	Do. B	229—234	80—84	..
528,500	"	"	10	4½%	Do. C	220—222	71—74	71½
133,301	Stk.	Sept. 12	4	4%	Shrewsbury 5 p.c.	..	..	..
90,000	10	May 28	9	10%	South African.	10½—11½	13—14	..
6,609,895	Stk.	Feb. 10	5/4/0	30/-	South Met. 4 p.c. Ord.	111—113	61—63	61—62½*
250,000	"	July 12	—	5%	Do. Pref.	..	96—98	..
1,895,445	"	July 10	8	8%	Do. 3 p.c. Deb.	72½—74½	54—56	..
224,820	"	Feb. 26	8½	5½%	South Shields Con. Stk.	164—169	99—101	..
952,795	"	"	6	3½%	S'th Suburb'n Ord. 5 p.c.	114—116	76—79	78
187,658	Stk.	June 26	5	5%	Do. 5 p.c. Deb. Stk.	116—118	89—92	..
647,740	"	May 14	7½	5%	Southampton Ord.	99—102	67—69	..
121,275	"	Dec. 30	4	4%	Do. 4 p.c. Deb. Stk.	..	64—66	..
120,000	"	Feb. 12		4½%	Tottenham — A 5 p.c.	135—138	90—95	..
783,275	"	"	6	3%	Tottenham — B 3½ p.c.	115—117	65—67	..
181,255	"	June 26	4	4%	Tottenham — 4 p.c. Deb.	87—89	55—57	65½—66
182,880	10	Dec. 30	5	—	Tuscan, Ltd.	5—6	1—2	..
142,900	10	July 1	5	5%	Do. 5 p.c. Deb. Red.	93—95	45—50	..
286,476	Stk.	Mar. 12	5	5%	Tynemouth 5 p.c. max.	108½—109	83—85	..
80,000	"	Feb. 26	8½	55/-	Wandsworth, Wimbledon, and Epsom— Wandsworth A 5 p.c.	151—156	88—93	..
256,838	"	"	6¼	40/-	Do. B 3½ p.c.	129—134	68—73	..
108,075	"	"	—	38/6	Do. C	..	68—73	..
140,865	"	"	—	38/6	New Ordinary	..	68—73	..
863,000	"	"	6½	33/9	Wimbledon 5 p.c.	117—122	64—73	..
98,000	"	"	6¼	40/-	Epsom 5 p.c.	121—126	70—75	..
88,416	"	June 26	8	8%	3 p.c. Deb. Stk.	66—69	50—52	..

* Ex Div.

Drogheda Gas-Workers' Strike.—The workmen at the Drogheda Corporation Gas-Works have gone on strike for higher wages and shorter working hours.

Debenham Gas Company, Ltd.—A private company has been registered with this title; the capital being £1500 in £1 shares. The object is to acquire gas-works carried on by Messrs. W. A. Scott and H. C. Walker at Debenham, Suffolk. The registered office is at No. 50, Cannon Street, E.C.

Gas-Meter Testing at Birmingham.—In his report to the Justices for the past year, Mr. Fredk. Colburn, Inspector to the City of Birmingham Gas-Meter Testing Committee, states that the number of meters tested was 25,364. This was an increase of 3908 as compared with the previous year, but a decrease of 61·2 p.ct. on the year ended March, 1914. The number of meters rejected as being incorrect was 1383, or 5·4 p.ct. Of 7933 wet meters tested, 541, or 6·5 p.ct., were rejected; and of 17,431 dry meters, 842, or 4·8 p.ct., were incorrect. Of the total number tested, 8438 were ordinary meters, 16,907 prepayment meters, and 19 high-pressure meters of the aneroid compensating type. The number of new meters submitted was 5003; while 20,262 were repaired meters, and 99 were consumers' meters requiring certification.

Dearer Gas at Evesham.—At last week's meeting of the Evesham Town Council, Alderman Fisher said it was doubtful if the advance in price of 5d. per 1000 c.ft. recommended would be the highest to which they would have to go. In the year ending March, 1915, coal cost £4600; and to make practically the same amount of gas last year the cost was £8390. Wages had increased from £2096 to £3706. All raw materials showed an upward tendency. With the advance, the price of gas would be: Prepayment installations, 3s. 9d. per 1000 c.ft. net; ordinary consumers, 3s. 9d. per 1000 c.ft., less 10 p.ct. discount for prompt payment; gas used for motive power (where the consumption reached 50,000 c.ft. and over per quarter), 3s. 4d. per 1000 c.ft., less 10 p.ct. It was proposed, added the Alderman, to extend the present system of retorts at an estimated expenditure of £3000. The Council approved the Committee's recommendations.

New Gasholder for St. Ives.—It was decided by the St. Ives (Cornwall) Town Council last Tuesday that application be made to the Local Government Board for sanction to the borrowing of £3000 in addition to the £4000 recently asked for, for improvements at the gas-works. Mr. M. W. Couch said that, in addition to improving the manufacturing plant, they needed a new holder, as the present one contained only gas enough for 24 hours' supply. They had about seventy applications from prospective gas consumers, but could not deal with them because of the inefficient plant. The Gas Manager said the Local Government Board Inspector, who held the inquiry in connection with the application for the £4000, suggested that they should apply for the additional sum in order to save the expense of another inquiry. The site proposed for the new holder was not an ideal one, being very hilly and rocky; but no doubt they would overcome this difficulty.

Opposition to Coal Nationalization.—Considerable activity is being shown by manufacturers in opposition to the proposals put forward for the nationalization of the coal mines. During the past week, meetings were held on the banks of the Thames on the Monday, and at Westminster on the Friday, for the purpose of considering resolutions on the subject. One of the resolutions passed unanimously at the former meeting was proposed by Mr. F. M'Leod, the Secretary of the South Metropolitan Gas Company, and was in the following terms: "That, in the opinion of the London Waterside Manufacturers' Association, the Coal Commission should make no report until due consideration has been given to the views of industries that are affected as consumers of coal. The appearance of comparatively few witnesses who represent consumers is not regarded as adequate to ascertain the effect on the industries of the nation of the proposal to nationalize mines."

Nottingham Public Lighting.—Nottingham's emancipation from irksome war conditions in regard to public lighting does not appear destined to prove of long duration; for there has been an announcement of the intention of the responsible Committee to revert in a large measure to the arrangements which obtained during the war period—the unwelcome decision being dictated in the interest of economy. Alderman A. Ball (the Chairman of the Gas Committee) foreshadowed the change at a recent meeting of the Corporation, when the city authorities were driven to largely increase the district rate; the total impost levied for municipal and poor law purposes now totalling 13s. in the pound. Except it may be at a few important junctions of traffic, public lighting is to be suspended for two months, with the consequent temporary stoppage of the services of a considerable number of lamplighters, a matter which has been taken up by the local branch of the National Union of General Workers, of which they are members. It is understood, however, that the Committee's reply to a deputation who waited upon them was that the decision will not be altered.

Presentation to Dundee Corporation Official.—An interesting function took place in the Gas Office, Commercial Street, Dundee, last Saturday week. Over 90 p.ct. of the recruitable staff went on active service; and as the men have been demobilized and returned to their old positions in the office, the female clerks and collectors have been gradually leaving. The staffs unanimously decided that this was a fitting opportunity to present Mr. W. M. Burke, the Gas and Electricity Treasurer and City Chamberlain, with a canteen of cutlery, as a token of the respect and good wishes which they entertain towards their Chief.

Teignmouth Gas Supply.—Discussion took place at a meeting of the Teignmouth Chamber of Commerce last Wednesday on the subject of the gas supply, and the proposals of Mr. W. Doig Gibb and the Manager (Mr. Harold Higham) for improving the works. Mr. J. Hayman said he understood the Council did not propose to carry out the large scheme of reconstruction which these gentlemen recommended, but to spend £600 on new retorts and other renovations. Mr. G. Dray complained of the present inadequate supply, and moved a resolution impressing on the Council the absolute necessity of immediately putting the gas-works into a condition which would enable them to give a continuous supply. Mr. Hayman remarked that before the war Teignmouth was one of the best-lighted towns in the West of England. There was then no shortage of gas. He did not think the ratepayers should agree to the borrowing of so large a sum as £22,000 for the gas-works. The resolution was carried unanimously.

The Bervie gas-works have been closed for the summer months. The price of gas has risen to a very high rate—stated to be the highest in Scotland.

John Budge, of Rochdale, was found dead in bed last Tuesday morning. Death was due to gas poisoning, caused by a slight escape in the room.

The General Workers' Union are asking the Bradford War Wages Committee for an advance of 10s. per week for all union men employed by the Corporation, and also for a 47-hour working week. The various departmental committees are being consulted before any definite decision is come to.

Mr. G. D. Bidwell (late Captain in the Wiltshire Regiment) has just been appointed to succeed Mr. Bromhead as agent, in the London and the Southern and Eastern Counties, for Messrs. Curtis's and Harvey, Ltd., of Cannon Street House, E.C., proprietors of the "Ironclad" brand of gas-mantles.

A conference on the "Benefit to the Workman of Scientific Management" will be held under the auspices of the Industrial Reconstruction Council, next Tuesday, at 5.30 p.m., in the Hall of the Institute of Journalists, Nos. 2 & 4, Tudor Street, E.C. Major Pells, R.E., will introduce the subject. No tickets are necessary.

At a meeting of the Directors of the South African Lighting Association, Ltd., held last Wednesday at the London Offices, it was resolved to pay a final dividend of 6 p.ct. for the half year ending Dec. 31, 1918, less income-tax at 5s. 9d. in the pound—making, with the interim dividend already paid, 10 p.ct. for last year. The dividend is payable on the 25th prox., and is subject to audit.

At the last meeting of the Halifax Borough Council, the applications of the chief officials of the Corporation for advances in their salaries were refused, though it was indicated that the various Committees could make recommendations for individual increases. On Wednesday last, the Gas Committee considered the position of the Gas Engineer and Manager (Mr. W. B. M'Lusky), and decided to recommend the Council that his salary be increased £100 per annum.

The "Daily Express" Model Homes Exhibition, at the Central Hall, Westminster, was visited last Tuesday by H.M. the Queen, whose interest was evinced at the stand of the Davis Gas-Stove Company, Ltd. The particular items of attraction were the Davis "Gascol" Patent Convertible Combination Gas and Coal Range for the National Housing Schemes, and the small working model of a new duplex reversible fire which the Company intend shortly to place on the market.

Referring to the working of the Askam gas undertaking, at a meeting of the Dalton Urban District Council last week, Mr. Pearsall said the Council ought to feel very grateful to the new Manager (Mr. R. Vickers) for the increased make of gas per ton of coal carbonized. Mr. Ward thought the Council should send a letter of congratulation to the Manager on the improvements effected at the works. They had been a bone of contention for a long time; and the Committee had been charged with mismanagement. The remarks of Mr. Pearsall might be the means of restoring confidence. Mr. Fisher thought the compliments paid to the Manager in public would meet the desire to acknowledge his services; and the Council agreed.

NOTICES TO CORRESPONDENTS, ADVERTISERS, AND SUBSCRIBERS.

No notice can be taken of anonymous communications. Whatever is intended for insertion in the "JOURNAL" must be authenticated by the name and address of the writer—not necessarily for publication, but as a proof of good faith.

WHITSUNTIDE HOLIDAY.

In view of the Whitsuntide Holiday, all communications for the next issue of the "JOURNAL" should reach the Office not later than the first post on Saturday.

Wanted, For Sale, and Tender Advertisements, Six Lines and under (about 40 words) 3s.; each additional Line, 6d.

TERMS OF SUBSCRIPTION to the "JOURNAL."

		ONE YEAR.	HALF-YEAR.	QUARTER.
United Kingdom	Advance Rate:	28/-	15/-	8/8
	Credit Rate:	32/-	16/-	9/6
Abroad (in the Postal Union) Payable in Advance		32/6	17/-	10/-

In payment of subscriptions for "JOURNALS" sent abroad, Post Office Orders or Bankers' Drafts on London only are accepted.

All Communications, Remittances, &c., to be addressed to WALTER KING, 11, BOLT COURT, FLEET STREET, LONDON, E.C. 4.

Telegrams: "GASKING, FLEET LONDON." Telephone: Holborn 6857.

OXIDE OF IRON

FOR SALE OUTRIGHT, OR ON LOAN.

SPENT OXIDE

PURCHASED IN ANY DISTRICT.

GAS PURIFICATION & CHEMICAL CO., LTD.,
Palmerston House,
Old Broad Street, London, E.C. 2

FOR Supplies of SULPHURIC ACID

ASK BERK.

W. BERK & CO., LTD.,
1, Fenchurch Avenue,
London, E.C. 3.

Works:
Stratford, London.
Morriston (Glam.).

Phone: 4082 Avenue. Tele: "Berk, Phone London."

SULPHURIC ACID.

SPECIALLY prepared for the manufacture of SULPHATE OF AMMONIA.

SPENCER CHAPMAN & MESSEL, LTD.,
with which is amalgamated Wm. Pearce & Sons, Ltd.,
Mark Lane, London, E.C. Works—Silvertown.
Telegrams—"Hydrochloric, Fen, London."
Telephone—1588 Avenue (3 lines).

BRITISH GAS PURIFYING MATERIAL.

ENGLISH BOG ORE AND NATURAL HYDRATED OXIDE OF IRON.
SPENT OXIDE BOUGHT.

BRITISH GAS PURIFYING MATERIALS CO., LTD.
(W. T. P. CUNNINGHAM, Chief Proprietor and Managing Director.)
13, Arcadian Gardens, Wood Green, London, N. 22.
Telegrams: "Bripurimat, Wood, London."
'Phone: Palmer's Green 608.

ALDER AND MACKAY, LTD.
(Established 1850).
WET AND DRY METERS,
SLOT AND ORDINARY.
STREET LAMPS AND AUTOMATIC CONTROLLERS.

EDINBURGH.
(See pp. 662 and 663.)

TULLY'S PATENT.
CARBURETTED HYDROGEN PLANT
for 300 to 500 B.Th.U.

COMPLETE GASIFICATION OF COAL.
BALE AND HARDY, LTD.,
39, Victoria Street, London, S.W.1.

J. E. C. LORD, Ship Canal Tar-Works, Weaste, Manchester. Pitch, Creosote, Benzols, Toluol, Naphtha, Pyridine, all kinds of Cresylic Acid, Carbolic Acid, Sulphate of Ammonia, &c.

"VOLCANIC" FIRE CEMENT.
Resists 4500° Fahr. Best for Gas-Works.
Andrew Stephenson, Gresham House, Old Broad Street, London, E.C. "Volcanism, London."

"FERROX." "FERROX." "FERROX."

A BRITISH Oxide Cheaper and Better than Bog Ore. 85 per cent. Water, 75 per cent. Ferric Hydrate.
For Sale outright or on Loan.
OXIDE LIMITED, Brentford, Middlesex.

SULPHATE OF AMMONIA
SATURATORS and all LEAD and TIMBER WORK in connection with Sulphate Plants.
We Guarantee promptness with efficiency for Repairs.
Joseph Taylor and Co., Chemical Plant Engineers, Bolton, Lancs.
Telegrams—"Saturators, Bolton." Telephone 0848.

J. & J. BRADDOCK (Branch of Meters Limited), Globe Meter Works, Oldham, and 45 & 47, Westminster Bridge Road, London, S.E. 1.
WET AND DRY GAS-METERS, PREPAYMENT METERS, STATION METERS AND GOVERNORS.
REPAIRS RECEIVE PROMPT ATTENTION.
Telephones: 815 Oldham, and 2412 Hop, London.
Telegrams—
"Braddock, Oldham," and "Metrique, Lamb, London."

BENZOL PLANTS FOR GAS-WORKS.

BAGLEY, MILLS, & CO., Ltd.,
92, Victoria Street, Westminster, S.W. 1, Invite inquiries from all Gas-Works making 75 million cubic feet and upwards per annum.

SPENCER'S Patent Inclined HURDLE GRIDS.

THE very best Patent Grids for Holding Oxide Lightly.
See Illustrated Advertisement, May 27, p. 519.

NEWBURN, ELLIS, AND PRYOR.
CHARTERED PATENT AGENTS AND
TRADE MARK AGENTS,
70, Chancery Lane, London.
Telegrams: "Patent, London." 'Phone: 248 Holborn.
And 8, St. Nicholas Buildings, Newcastle-on-Tyne.

EXTENSIONS.—Gas-Works requiring Alterations or Additions should Communicate with FIRTH BLAKELEY, SONS, AND CO., LIMITED, 15, Park Row, Leeds, who make a Speciality of Gas Apparatus, Coke-Oven Plant, and Structural Steel Work. Inquiries Solicited. Satisfaction Guaranteed. Telephone No. 22579, Leeds.

PATENTS — Inventors, Advice and Handbook free.
King's Patent Agency, Ltd., 165, Queen Victoria Street, London, E.C. 4.

APPOINTMENTS, &c., WANTED.

WHEN Filling Vacancies, please REMEMBER THE CLAIM OF THE EX-SERVICE MAN, who, other Qualification being equal, has the FIRST CALL ON YOUR CONSIDERATION.

COOKERY Lecturing and Advisory WORK.—First-Class Diplomée of National Training School of Cookery, with 14 Years' Experience in all Branches of Cookery Lecturing, desires Change. Travelling or South of England preferred. French spoken.
Address No. 6609, care of Mr. King, 11, Bolt Court, Fleet Street, E.C. 4.

GAS PUBLICITY.

SECRETARY of a Lancashire Gas Company desires Change to a more progressive Company or Council. Initiative, Energetic, Good Address. Willing to serve as Assistant Secretary or Organize Development or Extension of Business. Able to Advise Consumers.
Address No. 6677, care of Mr. King, 11, Bolt Court, Fleet Street, E.C. 4.

ADVERTISER, 4½ years Army, Well Educated, Thirty Years of Age, Eight Years' good all-round Experience in 500 Million Works as GENERAL ASSISTANT and DRAUGHTSMAN seeks similar Position.
Address, No. 6678, care of Mr. King, 11, Bolt Court, Fleet Street, E.C. 4.

APPOINTMENTS, &c., VACANT.

GENERAL Manager wanted for Engineering Works in the North of England manufacturing Gas-Retort Installations, Elevating and Conveying Machinery, and Colliery Plant. One with the necessary Experience, Tact, and Ability, able to Interview Prospective Customers and carry the Work through will find this a Position with Excellent Prospects.
Apply, by letter, stating fullest Particulars and Salary, to No. 6676, care of Mr. King, 11, Bolt Court, Fleet Street, E.C. 4.

WANTED—Manager for Works. Make 10 Mill ons. House found.
Apply, by letter, stating Salary required, to No. 6675, care of Mr. King, 11, Bolt Court, Fleet Street, E.C. 4.

OXIDE OF IRON.
SPENT OXIDE BOUGHT.

BALE & CHURCH, LTD.
33, St. Mary at Hill, London, E.C. 3.
Phone: Avenue 6680.

"TORTO" FIRE CEMENT.

BALE & CHURCH, LTD.
33, St. Mary at Hill, London, E.C.
Phone: Avenue 6680.

"KLEENOFF," THE COOKER CLEANSER.
Tins for Sale to Consumers.
In Bulk for Works Use.

BALE & CHURCH, LTD.
33, St. Mary at Hill, London, E.C. 3.
Phone: Avenue 6680.

LANCASTER CORPORATION.
(Gas Department.)

THE Gas Committee invite Applications for the Position of SUPERINTENDENT of their Gas-Works.
Applicants must possess a thorough knowledge of Modern Carbonizing Plant, Mechanical and Electrical, Carburetted Water-Gas, other Gas-Works Plant, Chemistry and Drawing, &c., &c.
Salary, £250 per Annum.
Applications, stating Age, Qualifications, and Experience, together with Three recent Testimonials, endorsed "Superintendent," to be delivered to C. Rhodes Armitage, Engineer and Manager, not later than June 9, 1919.

T. Cann Hughes, M.A.,
Town Clerk.

Gas-Works, Lancaster,
May 26, 1919.

DRAUGHTSMAN, Estimating, required by Constructional and General Engineers in the Birmingham District. Experience in Gas-Works and/or Coke-Oven Plant a Recommendation.
Apply by letter, stating Age, Experience, and Salary required, to No. 6662, care of Mr. King, 11, Bolt Court, Fleet Street, E.C. 4.

WANTED for a Provincial Gas- Works a DRAUGHTSMAN with Experience in Gas-Works plant. One with a knowledge of Chemistry and Capable of Acting as Assistant to the Engineer preferred.
Apply, by letter, stating Qualifications, Experience, and Salary required, to No. 6670, care of Mr. King, 11, Bolt Court, Fleet Street, E.C. 4.

DRAUGHTSMAN.—Junior Draughts- MAN wanted by the Bristol Gas Company.
Apply, stating Age, Experience, and Salary required, to R. Robertson, Engineer, Gas Offices, Colston Street, Bristol.

WANTED—Working Foreman for the Goole Gas-Works. Must have had Experience in the Retort-House, possess a good knowledge of Gas-Works Routine, and accustomed to Control Workmen. Wages, £3 per Week, with House, Coal, and Gas provided free.
Apply, before the 18th of June, to the Chairman, Gas-Works, Doyle Street, Goole.

WANTED—Retort-House Foreman, with Experience in Carbonizing and the usual Gas-Works Plant. One with Mechanical knowledge preferred.
Apply, by letter, giving Details of Experience and Wages required, to No. 6669, care of Mr. King, 11, Bolt Court, Fleet Street, E.C. 4.

EDINBURGH AND LEITH CORPORATIONS' GAS COMMISSIONERS.

GRANTON WORKS.

MANAGING Foreman wanted to Take Full Charge of the Granton Works, under the Direction of the Engineer and Manager.
Applicants must have had a Mechanical Training and be thoroughly Experienced with every Detail of the Equipment of a Large Modern Gas-Works, and Competent to Supervise the Daily Routine in all its Ramifications, as well as the Supervision of the Annual Repairs and Renewals, all of which are carried out by the Commissioners' own Staff.
Applications, giving a *resume* of the Early Training and Past Experience, setting forth in Detail the Types of Carbonizing and other Plant with which the applicant has had Experience, together with *copies* of Testimonials, stating Age (which must not exceed 40) and other Particulars, are to be addressed to the undersigned on or before Saturday, *June 7*, 1919.
Salary, £300 per Annum, with House, Coal, and Gas.
As the appointment is due to retiral, owing to the present occupant having arrived at the pension age, the Position will become Vacant about the end of July.
Canvassing any member of the Commission is strictly prohibited.

Alexander Masterton,
Engineer and Manager.

RETORT-HOUSE Foreman required by a Gas-Works in the South of England producing over 800,000,000 c.ft. per Annum. A Good Wage will be paid. Eight-Hour Shifts. Only those who are thoroughly Experienced in Retort-House Work need apply.
Applications, stating Age and Experience, to be sent as soon as possible to No. 6666, care of Mr. King, 11, Bolt Court, Fleet Street, E.C. 4.